3.1 RECYCLING OPTIONS OF E-WASTE

E-waste contains more than 1000 different substances, many of which are toxic such as lead, mercury, cadmium, selenium and hexavalent chromium etc. However, in major classifications, five types of materials are found to be predominant viz., ferrous metals, non ferrous metals, precious metals, glass, plastics and others. Among these, the precious metal flow is one of the key economic drivers of the Material Recovery Facility (MRF) processes. The high material value of gold and concentrations of this valuable material utilization up to 4g per PC create strong interest to recover these material fractions. Figure 3.1 shows the graphical representation of the components and composition of E-waste.

Figure 3.1 Components and composition of E-waste
Martin Streicher et al (2005) in one of the previous studies reported about the assessment and modeling e waste processing in the informal sector in Delhi. In this study, a first outline was drawn suggesting how much a method could be applied to an informal recycling sector such as the one in New Delhi, the capital of India. Approximately 85,000 people are estimated to work in this sector, a lot of whom are immigrants from other Indian states such as West Bengal, Bihar or Uttar Pradesh and neighbouring countries such as Bangladesh. The author described that solid waste management and recycling are organized by an informal industrial sector. However, the author on further analysis confirmed that by comparing the EU directive on WEEE, some practices of informal industries in developing industries already conform to legal requirements. The manner in which the Indian recycling system deals with these fractions is illustrated in the Figure 3.2.

![Figure 3.2 Simplified flow Diagram for the Recycling of an Electronic Product](image)

Figure 3.2  Simplified flow Diagram for the Recycling of an Electronic Product
3.1.1 Recovery Process for CRTs

Cathode ray tubes are the major items in electronic recycling due to their volume, recycling costs and disposal restrictions. A CRT consists of two major parts. One is the glass components (funnel glass, panel glass, solder glass, neck) and other is the non glass components (plastics, steel, copper, phosphor coating). CRT glass consists of SiO$_2$, NaO, CaO and other components for coloring, oxidizing etc. CRTs contain lead (Pb), hence proper handling is necessary to avoid contamination of air, soil and ground water Hai yong et al (2005). There are two technologies currently available for CRT recycling. One of the methods is glass to glass and the other option is glass to lead recycling. Till date, the preferred process for the disposal of CRT glass is to recycle it into new CRT glass. The list of activities involved in the recycling of CRTs is illustrated in Figure 3.3

![Figure 3.3 Process Flow Diagram for Recycling of CRTs](image)

3.1.2 Recovery Process for Metals

The metal fractions of the recycling Process are iron, aluminium, copper and precious metals (gold, palladium, platinum, silver). These
fractions are probably recycled in smelters, as they form a flow of certain valuable materials. The nonferrous metals are a mixed flow of a whole range of metals. A magnetic separator can separate ferrous components and the overhead belt magnet is the most common magnetic separation system. After shredding, particles are moved on the conveyor belt over the magnet. The ferrous metal particles adhere to the belt because of the magnetic attraction, and the nonferrous metals are dropped into a nonferrous metals collection bin by gravity. The ferrous metal particles remain attached to the belt and are carried away from the remaining particles and dropped into a collection bin when they are no longer affected by the magnetic field. Figure 3.4 outline the separation processes of various components of E-waste.

Figure 3.4  Simplified Schematic of the Process Steps at a Materials Recovery (MRF)
3.1.3 Recovery Process for Nonferrous Metals

Eddy current separators can remove non-ferrous metals such as aluminium and copper from non-metallic materials. When a piece of non-ferrous metal, such as Aluminium or Copper, passes over the separator, the magnets inside the shell rotate at high speed. This forms eddy currents in aluminium, which in turn creates a magnetic field around the piece of aluminium. The polarity of that magnetic field is the same as the rotating magnet, causing aluminium to be repelled away from the magnet. This repulsion makes the trajectory of the aluminium greater than that of the non-metal, allowing the two materials to be separated. Based on the conductivity-to-density ratio, the other nonferrous metal category of metals that can be recovered through eddy current separators are Zinc, Silver, Copper, Brass and Lead (Hai Yong et al 2005). At a subsequent electrolytic refining process, the precious metals gold, silver, palladium and platinum are recovered.

3.1.4 Recovery Process For Plastics

During the E-waste recovery process, plastics constitute the third largest flow Hai Yong et al (2005). Plastics in electrical and electronic equipment are highly visible, for instance in telephones, televisions and personal computers. However, there are also many plastic components, hidden from view, that provide the infrastructure to connect and support modern lives. The unique electrical insulating properties of plastics and their strength, stress resistance, flexibility, and durability make plastics important materials for use in electronics. The two major types of resins of plastic used in electronic goods are thermosets and thermoplastics. Generally, thermoset plastics are shredded when recycled, because they cannot be re-melted and cast into new products (Subramanian 2000).
Thermoplastics are used in a wide variety of applications within computers and other electronic devices. These types of resins can be remelted and formed into new products. Thermoplastics show better recyclability than thermosetting plastic resins and possess good intrinsic value also. There are three types of recycling processes adopted in recycling of commingled plastics. Chemical recycling processes use waste plastics as raw materials for petrochemical processes or as a reluctant in a metal smelter. Mechanical recycling is a conventional method, which uses a shredding and identification process to eventually make new plastic products. In thermal recycling, plastics are used as an alternative fuel. Figure 3.5 depicts the recycling process and end products.

Figure 3.5 Recycling Options for Managing Plastics from End-of-life Electronics

3.2 RECYCLING OPTIONS OF WASTE E-PLASTIC

Plastics have become an integral part of our lives. The amount of plastics consumed annually has been growing steadily. Its low density,
strength, user-friendly design, low cost and fabrication capabilities are the drivers to such growth. The usage of plastics, in preservation and distribution of food, housing and appliances are too many to mention here. Specially designed plastics, have been an integral part of the communication and electronics industry in the form of printed circuit boards, in the manufacturing of chips and housings for computers.

According to the informations of Plastics information home page, nearly 20 percent of a computer is made up of plastics-primarily Alpha Butadiene Styrene (ABS) used for making Central Processing Unit (CPU) and keyboard housings. Plastics actually substituted for metals, especially in CPU and keyboard housings. In recent years, even Polycarbonate is used to enhance the aesthetics. ABS plastics are a high quality plastic and harder than most other varieties. In addition to ABS plastics, the major category of resins used in Computers, TV sets are High impact polystyrene (HIPS), Polyphenylene oxide (PPO) etc.

Their hardness and the requirement of specialized equipment for their recycling discourage its retrieval. In Chennai, the ABS plastics from computer components are separated and sold on weight basis to plastic recyclers. These recyclers collect ABS plastics from various other resources, and after pelletizing them, pack them off to Mumbai or Delhi where the pellets are recycled into chairs and trays. According to experts from the Central Institute of Plastics Engineering and Technology (CIPET), there is very little chance of this coming back to the IT manufacturing stream.

The amount of WEEE generated constitutes one of the fastest growing waste fractions, accounting for 8% of all municipal waste (The Economist, 2005). The report issued at Simultaneous extraordinary meetings of the Parties of Basel, Stockholm, predict that Global E–waste generation is growing by about 40 million tonnes a year. The report also estimates that the
current E-waste scenario in India today has broken down by type, 100,000 tonnes from refrigerators, 275,000 tonnes from TVs, 56,300 tonnes from personal computers, 4,700 tonnes from printers and 1,700 tonnes from mobile phones etc. Most of the earlier reviews confirmed the generation of waste plastic out of these electronic scrap ranging from 21% to 30%. They are integrated with several other plastic and non plastic components. Their separation, recovery and purification require several steps and nevertheless, several efforts are underway exploring the recycling of volumes of such materials. To recycle plastics from discarded electronics, the order of actions begin with sorting, cleaning and additional size reduction processing. This will result in generation of uniform sized particles that can be utilized effectively for downstream recycling applications.

3.3 RESEARCH SIGNIFICANCE

Presently plastics which are recycled are sorted into constituent types and then melted down before they can be reused. This requires vast amount of manpower and processing costs. Accordingly only a small fraction of plastics used are recycled, the rest going into landfills, incinerators and dumps. There is clearly a long felt need for a way to reuse plastics without requiring such extensive effort and excess cost involved.

It is necessary to arrive at a cost effective and environmental friendly recycling process and representative facilities employing environmentally sound technologies and methods for recycling and recovery are to be evolved.

The incorporation of plastics into building materials has dual advantages that the requirement of materials is reduced and the another aspect is that waste plastic which presents an ever increasing disposal problem, is
thus recycled without further encumbering waste treatment and storage facilities (Subramanian 2000).

Chen et al (2006) reported the scope for utilization of waste glass in concrete in several forms including fine aggregate and coarse aggregate. Several publications suggested the applications of glass cullets as concrete aggregate, Road construction aggregate and building applications (Bricks, Tiles, Wall panels etc). The utilization of waste plastic components of E-waste as weight percent to coarse aggregate in concrete as filler material is the major interest of the work reported here.

The divided particle size of waste E-plastic particles is determined to be between 1.18mm – 2.36mm. The usage of waste E-plastic particles was considered as filler material in cement concrete in various percentages. The waste E-plastic contents were calculated as weight percent of coarse aggregate in the control mix.

### 3.4 SCOPE OF INVESTIGATION

The use of non-hazardous and biologically non-degradable-plastic components of E-waste in cement concrete as filler material has been focused in this investigation as a viable solution to the problem of recycling costs and high disposal costs. The specific objectives of the study are:

- To identify and understand the diversified sources of Waste Electrical and Electronic Equipments – WEEE waste stream.
- To review the assessment of the current and future trends of growing Volume of E-waste including quantification, characteristics, existing disposal practices and environmental impacts etc.
To present the Reduce, Reuse, Recovery, and Recycling concepts of waste management strategies and the potential options essential for an environmental friendly recycling procedure for waste E-plastic.

To propose a methodology to utilize the non-hazardous and non-recyclable plastic components of E-waste which is crushed and ground to the particle size for the effective usage as filler material in concrete.

To explore the impact of the presence of waste E-plastic on the properties of fresh and hardened concrete containing waste E-plastic as filler material.

To investigate the influence of waste E-plastic filler material on the durability parameters of concrete.

To establish an environmentally sound recycling system for waste E-plastic and to arrive at inherently sustainable solutions for E-waste management.