

# DEVELOPMENT OF SUSTAINABLE BONDING AGENT TO IMPROVE PLASTIC WASTE-CEMENT PASTE ADHESION IN CONCRETE

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**Abstract**— The fast increase in waste or e-waste is a big problem for the environment. This is especially true because of plastics like Acrylonitrile Butadiene Styrene or ABS and High-Impact Polystyrene or HIPS that come from keyboards. These plastics do not break down easily. Do not mix well with cement.

The electronic waste plastics have characteristics that make it hard for them to bond with materials. This study is about a product called Eco-Derived Adhesion Promoter or EDAP. The Eco-Derived Adhesion Promoter is made from a kind of epoxy resin that comes from natural sources. It helps waste plastic and cement work together better.

People looked at how strong the waste plastic and cement mixtures were. They tested how much weight the mixtures could hold how much they could bend and how well they stuck together. They also used tools to look at the tiny structure of the mixtures. The results showed that the electronic waste plastic mixtures that were treated with Eco-Derived Adhesion Promoter were stronger. They could hold weight bend more and stick together better than the mixtures that were not treated.

The special tools showed that the mixtures had a bond, between the electronic waste plastic and the cement. This is because the Eco-Derived Adhesion Promoter helped the waste plastic and the cement work together. The findings of this study are important because they show that electronic waste plastic can be used in a way. The Eco-Derived Adhesion Promoter makes it possible to use waste plastic in construction, which helps the environment and supports the idea of reducing waste.

**Keywords**—E-waste management, Acrylonitrile Butadiene Styrene (ABS), High Impact Polystyrene (HIPS), Eco-Derived Adhesion Promoter (EDAP), polymer-cement composites, mechanical properties

## I. INTRODUCTION

### 1.1. Introduction to Eco-Derived Adhesion Promoter (EDAP)

The speed at which technology is moving forward is causing a huge increase in electronic devices being thrown away all over the world. The Global E-Waste Monitor says that in 2023 we are getting rid of about 59 million tonnes of waste every year and about one-fifth of this waste is made of plastic. A lot of this waste comes from computer parts like keyboards and screens which are made from

strong plastics like Acrylonitrile Butadiene Styrene and High-Impact Polystyrene. These materials are very hard to break down so when we throw them away, they can hurt the environment.

At the time the construction industry is using a lot of the worlds natural resources, which is causing problems. It uses 40% of all resources and makes about 8% of all the bad carbon emissions, which is mostly from making cement. This shows that we need to find ways to build that are better for the environment.

One way to solve both of these problems is to use electronic waste to make new building materials. It is hard to mix old plastics with cement because they do not stick together well. The plastic does not like water. The cement needs water so they do not work well together. This means that the material we make is not strong.

To fix this problem we are trying to make a helper called an Eco-Derived Adhesion Promoter. This helper is made from a kind of epoxy that comes from nature and it will help the old plastic stick to the cement. We hope that this will help us make building materials that are good, for the environment and use old electronic waste in a responsible way. This way we can help keep the earth clean and make construction more sustainable.

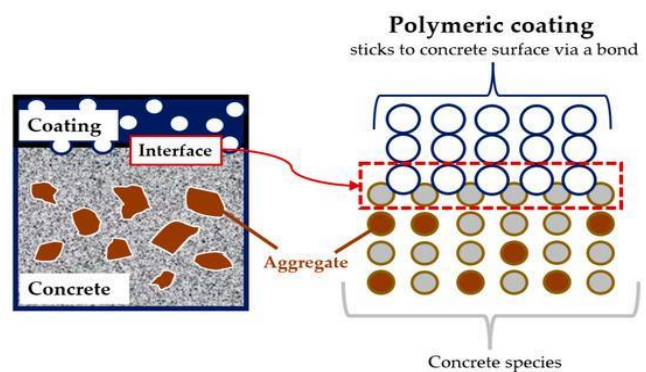


Figure 1.1. Polymeric Coating

#### 1.1.1. Need for suitable alternative

The construction industry is growing worldwide. This growth, combined with the availability of natural resources and the increasing amount of waste makes it essential to develop materials that are both strong and environmentally friendly. Using waste from electronic

devices in cement-based materials offers two significant benefits.

Firstly reusing -biodegradable plastic waste reduces the amount of waste sent to landfills, which in turn decreases environmental pollution and long-term damage to ecosystems. Secondly using plastic instead of raw materials helps conserve natural resources supporting the idea of a circular economy where materials are reused and recycled.

However, adding untreated plastic waste from electronic devices to cement-based materials poses technical challenges. The smooth surface of these plastics and their non-reactive nature make it difficult for them to bond well with the cement.

This poor bonding creates gaps inside the material. Reduces its strength. Previous studies have shown that this can decrease strength by 15 to 30%. To overcome this challenge this research project focuses on developing a surface treatment using natural materials.

This treatment aims to improve the bonding between the waste and the cement enhancing the overall performance of the material. By using waste and natural surface treatments this project seeks to create stronger more sustainable materials, for construction. The goal is to support an economy and reduce environmental impact.

## 1.2. Background

### 1.2.1 E-Waste Plastics and Environmental Concern

The world is producing a lot of waste. Every year, then 59 million tonnes of electronic waste are generated globally. This waste includes plastics from computers like Acrylonitrile Butadiene Styrene (ABS) and High-Impact Polystyrene (HIPS). These plastics do not break down easily. Can harm the environment if not disposed of properly. We need to find ways to recycle them in a way.

### 1.2.2 E-Plastic Aggregates in Cement Composites

Using waste plastics in concrete is being explored as a way to reduce waste and conserve resources. However, studies have shown that adding plastics to concrete can make it weaker. This is because the plastics do not bond well with the cement. The shape and surface of the plastics also make it harder for them to work well with the cement. As a result, the concrete may not be as strong with some studies showing a 15-30% decrease in strength.

### 1.2.3 Surface Treatment Approaches

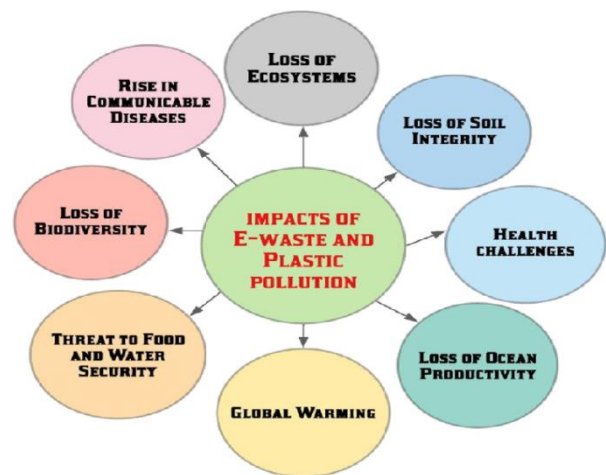
Researchers have tried methods to improve how plastics bond with cement. These methods include roughening the surface of the plastics using chemicals and adding other materials like silica fume and fly ash. Some of these methods have been shown to work. They often use chemicals that can harm the environment.

### 1.2.4 Bio-Based Epoxy Resins as Green Bonding Agents

Bio-based epoxy resins are being developed as an environmentally friendly alternative to traditional adhesives. These resins are made from materials like vegetable oils and can improve the bonding between plastics and cement. They have functional groups that help them bond well with both plastics and cement.

### 1.2.5 Research Gap

Although there is growing interest in using plastic aggregates in concrete there is still a lot to be learned about using bio-based adhesion promoters specifically designed for e- plastic-cement systems. This study aims to fill that gap by developing an Eco-Derived Adhesion Promoter (EDAP) based on -modified epoxy resin. The goal is to improve the bonding, between plastics and cement make the concrete stronger and promote construction practices.



**Figure 1.2 Impacts of E-waste and Plastic Pollution**

## 1.3. Significance of the project

### 1.3.1 Environmental Perspective

India is one of the producers of electronic waste generating over 1 million tonnes every year.. Only a small part, less than 20% is recycled properly. The rest, which is mostly made of plastic that does not break down ends up in landfills where it stays for a time. This waste slowly releases chemicals into the soil and water around it. Using these materials to make cement-based composites is a way to reduce waste and help the United Nations achieve its goals especially when it comes to new industries, sustainable cities and using resources wisely.

### 1.3.2 Resource Efficiency

When we use plastic to replace some of the regular materials in cement, we need less cement to make the same amount of composite. This means we use energy and

produce less carbon dioxide, which is good for the environment. Also, plastic is lighter than materials so it helps make lighter composites. This is useful for building things that do not need to be very strong, like walls that divide rooms pavement blocks and panels that fill in spaces.

### 1.3.3 Technological Innovation

This study is about a product called Eco-Derived Adhesion Promoter or EDAP for short. It is a coating made from plants that helps cement and plastic stick together well. Unlike products that are made from petroleum EDAP is safe for the environment does not harm people and comes from renewable sources. Using EDAP makes the cement composite stronger in ways, which is a big improvement. Electronic waste, like computers and phones can be used to make these composites, which helps reduce electronic waste and supports the United Nations goals, such, as sustainable development and responsible consumption of resources.

### 1.4. Research Objective

1. To develop an eco-friendly bonding agent enhancing adhesion between plastic waste particles and cement paste.
2. To study the influence of this bonding agent on mechanical and durability properties of concrete.
3. To promote sustainable use of plastic waste in civil engineering applications.

### 1.5. Scope and Problem Definition

This study is about making something in a laboratory. We are working with plastic waste and trying to make it stick to cement. The problem is that old plastic waste does not mix well with cement because one is water loving and the other is not. When we mix them together, they do not stick well. The material is not strong.

We are not looking at how this works in the real world or how it will last over time. Those things are for another study.

The old plastic waste we are using is from things like computers and televisions. It is very hard to make it stick to cement. Most of the ways we treat the surface of the plastic waste now are not good for the environment. We need to find a way to make it stick that is good for the environment.

That is why we made something called the Eco-Derived Adhesion Promoter. The Eco-Derived Adhesion Promoter is a helper that makes the old plastic waste stick, to the cement. We think the Eco-Derived Adhesion Promoter is a solution because it is natural and renewable. The Eco-Derived Adhesion Promoter can help us use plastic waste to make new building materials. This is a deal because we can help the environment by using old plastic waste and the Eco-Derived Adhesion Promoter.

## II. LITERATURE SURVEY

### 2.1. Literature Review

The utilization of recycled plastic waste within cementitious composite systems has steadily gained prominence as a research priority in the field of sustainable civil engineering. Over the preceding two decades, considerable scientific effort has been directed toward investigating a range of surface modification methodologies and interfacial coupling strategies aimed at improving the physicochemical compatibility between hydrophilic cement matrices and hydrophobic polymeric inclusions. While meaningful advancements have been achieved, the simultaneous attainment of strong interfacial adhesion, uniform aggregate dispersion, and long-term composite durability continues to represent a formidable scientific and technological challenge.

This chapter presents a comprehensive review of existing studies on

- (1) the use of e-waste plastics in cement composites.
- (2) epoxy-based and bio-derived adhesion promoters.
- (3) methods used to evaluate composite performance.

The objective is to highlight the limitations of current solutions and establish the need for developing a specialized eco-derived adhesion promoter for improved performance in e-waste-based cement systems.

### 2.2. Literature Survey

[1] Gupta et al. Studied the use of keyboard plastic as a replacement for fine aggregate in cement mortar. They found that using 10% keyboard plastic reduced the compressive strength by 20%. However, it made the mix easier to work with. Reduced the overall weight. The problem was that the plastic did not bond well with the cement, which made it weaker.

Gupta et al. Discovered that using keyboard plastic is good for reducing weight and waste but it has some drawbacks. The plastic does not stick well to the cement, which makes it weaker.

[2] Liu and Feng looked at using ewaste plastic powder in cement. They found that it reduced the strength by 15-25%. The reason was that the plastic powder did not stick well to the cement. The surface of the powder was smooth and did not react with the cement, which made it weak.

Liu and Feng realized that the plastic powder needs to be treated before it can be used in cement. This will help it stick better to the cement and make it stronger.

[3] Pradhan et al. Studied the use of waste plastic fibers in self-compacting concrete. They found that the fibers helped prevent cracks. Reduced the compressive strength. The fibers acted like bridges that stopped the cracks from spreading. However, they also made the cement matrix weaker.

Pradhan et al. Found that using waste plastic fibers has its pros and cons. It helps prevent cracks. Makes the concrete weaker.

[4] Subramanian et al. Created a hybrid cement composite using 5% e- plastic and silica fume. They found that the silica fume helped improve the bond between the plastic and the cement. The hybrid mix was 10% stronger than the mix with plastic.

Subramanian et al. Discovered that using silica fume with e- plastic can make it stronger. The silica fume helps the stick better to the cement.

[5] Yadav et al. Studied the effect of alkali-based chemical treatment on ABS plastic flakes. They found that the treatment made the surface of the plastic rougher, which helped it stick better to the cement. The treated plastic was 9% stronger than the plastic.

Yadav et al. Realized that treating the plastic surface can make it stick better to the cement. This can make the concrete stronger.

[6] Ahmad et al. Used silane coupling agents to treat HDPE plastic particles. They found that the treatment improved the bond between the plastic and the cement. The treated plastic was 6-8% stronger than the plastic. However, the treatment process was not environmentally friendly.

Ahmad et al. Discovered that using silane coupling agents can make the plastic stick better to the cement. However, the process is not good for the environment.

[7] Kumar and Patel studied the use of epoxy resin as a surface coating for e- plastic aggregates. They found that the coating improved the bond between the plastic and the cement. The coated plastic was 10% stronger than the plastic. However, the epoxy resin was not environmentally friendly.

Kumar and Patel realized that using epoxy resin can make the plastic stick better to the cement. However, it is not good for the environment.

[8] Sharma et al. Studied the use of polyurethane coatings on recycled plastic aggregates. They found that the coating improved the bond between the plastic and the cement. Made the concrete more brittle. The coating was not consistent which made it weaker.

Sharma et al. Discovered that using polyurethane coatings can make the plastic stick better to the cement. However, it can also make the concrete more brittle.

[9] Basheer et al. Used plasma surface treatment to modify waste plastic aggregates. They found that the treatment improved the bond between the plastic and the cement. However, the process was not scalable and required equipment.

Basheer et al. Realized that using plasma surface treatment can make the plastic stick better to the cement. However, it is not practical for large-scale use.

[10] Wong et al. Proposed a solvent-activated coating system for waste plastic aggregates. They found that the coating improved the bond between the plastic and the cement. However, the coating process was not environmentally friendly.

Wong et al. Discovered that using a solvent-activated coating system can make the plastic stick better to the cement. However, it is not good, for the environment.

[11] Tan and Rahman in 2016 made an epoxy resin from soybean oil. They said it could replace epoxy made from Bisphenol-A. This new resin worked as well as regular epoxy but was better for the environment. They showed that epoxy made from oil can work just as well as regular epoxy.

[12] Zhang et al. In 2017 looked at epoxy made from castor oil. They used it as a coating between steel and cement. This epoxy worked better in temperatures than regular epoxy. It also stuck well to both steel and cement. They said it could be used where strong bonding is needed.

[13] Nair et al. In 2018 made epoxy from lignin. They said it was good for the environment. This epoxy worked well. Had 80% less bad emissions than regular epoxy. They said it could be used where being green is important.

[14] Mehta et al. In 2019 looked at epoxy made from cardanol. They used it as a coating in cement. Cardanol helps the coating stick to cement and plastic. They said it worked well and was good for the environment.

[15] Amin et al. In 2020 added special clay particles to bio-epoxy. This made the epoxy stick better to cement. It also made it stronger when wet. They said it was a way to make bio-epoxy work better.

[16] Park et al. In 2021 looked at how temperature affects bio-epoxy. They said 60°C was the temperature to make it strong. If it's too hot or too cold it doesn't work well. They gave guidelines on how to use bio-epoxy.

[17] Das and Singh in 2022 made an epoxy from palm oil and glycerol. They said it worked 22% better than epoxy. It

stuck well to cement because of its mix. They said it could replace epoxy.

[18] Li and Chen in 2018 looked at how cement and polymer work. They said it's about how well they mix. If they don't mix well, it can be weak. They said it's important to make sure they mix well.

[19] Marques et al. In 2020 looked at how epoxy coating works with cement. They said it makes a bond. They saw that epoxy goes into the pores of the aggregate and makes it strong. They also saw that it forms bonds with cement.

[20] Hassan et al. In 2021 looked at how polymer coatings work with cement. They said it forms bonds. They saw that it makes the bond stronger and more durable. They said it's not, about sticking together but also about forming special bonds.

[21] Ghosh and Reddy did a study in 2021. They used a kind of modeling to see how strong the bond is between polymer and cement. They found out that the surface of the polymer coating is very important. If the surface is more polar it means the polymer and cement stick better. This is because the molecules are more attracted to each other. So, when the surface polarity is higher the bond between the polymer and cement is stronger.

[22] Rajendran and his team did a study in 2022. They looked at how the roughness of the surface and the polar groups on the epoxy coating affect the bond between the epoxy and cement. They found out that both of these things are important. The roughness helps the epoxy and cement lock together mechanically. The polar groups help them bond chemically. When the epoxy coating is both rough and has a lot of groups the bond is the strongest.

[23] Othman and his team did a study in 2021. They added epoxy to concrete to see how it affects its strength. They found out that adding an amount of epoxy makes the concrete stronger. This is because the epoxy fills in the pores and helps the paste bond together. The epoxy makes the concrete more resistant to compression and flexure.

[24] Rao and his team did a study in 2022. They compared the strength of concrete made with plastic aggregates and concrete made with epoxy-coated plastic aggregates. They found out that the epoxy-coated aggregates make the concrete stronger. However, the epoxy coating also makes it harder to mix the concrete. This is because the epoxy changes the surface of the aggregates and makes them more viscous.

[25] Khalid and his team did a study in 2023. They tested the durability of concrete made with polymer and plastic aggregates. They found out that the concrete made with bio- treated plastic aggregates is more resistant to acid and

water. This is because the bio-epoxy treatment makes the bond, between the polymer and cement more stable. The treatment reduces the number of pores. Makes it harder for aggressive agents to penetrate the concrete.

### III.METHODOLOGY

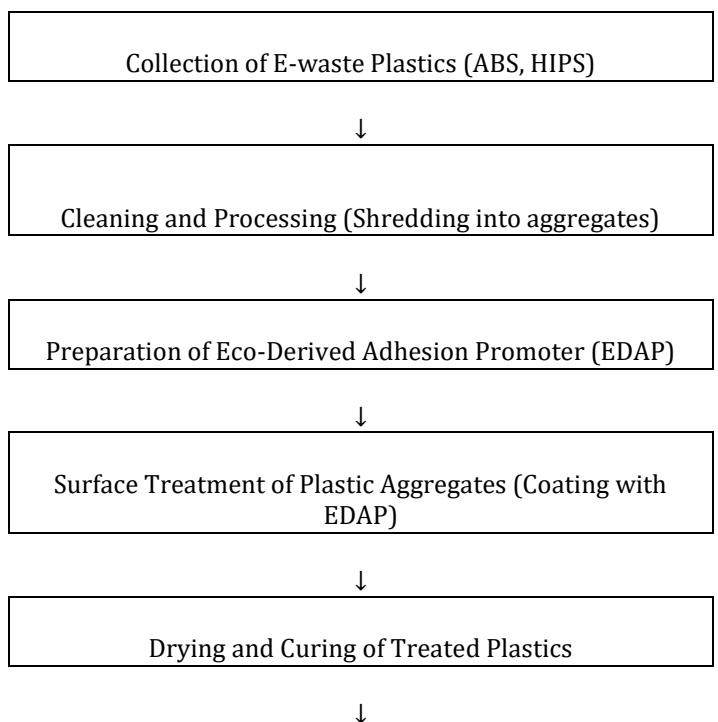
#### 3.1 Introduction

This study is about finding a way to make e-waste plastic stick better to cement. We want to make a mixture that will help e-waste plastic and cement paste stick together. To do this we will take plastic clean it up and then use a special helper called Eco-Derived Adhesion Promoter. This helper is made from a kind of epoxy that comes from natural things.

We will then mix the cleaned plastic with cement to see if our special helper works. We will test the mixture to see how strong it is. We will do lots of tests like squeezing it bending it and pulling it apart to see how it holds up.

We will also use tools like a super powerful microscope and a special light to look really closely at what is happening between the e-waste plastic and the cement. This will help us understand how well the e-waste plastic and cement are sticking together.

By doing all these tests we can find out if our special mixture is any good and if it is good for the environment. We can see if it is strong if it sticks well and if it is sustainable. This means we can find out if our e- plastic and cement mixture is a good solution, for building things.



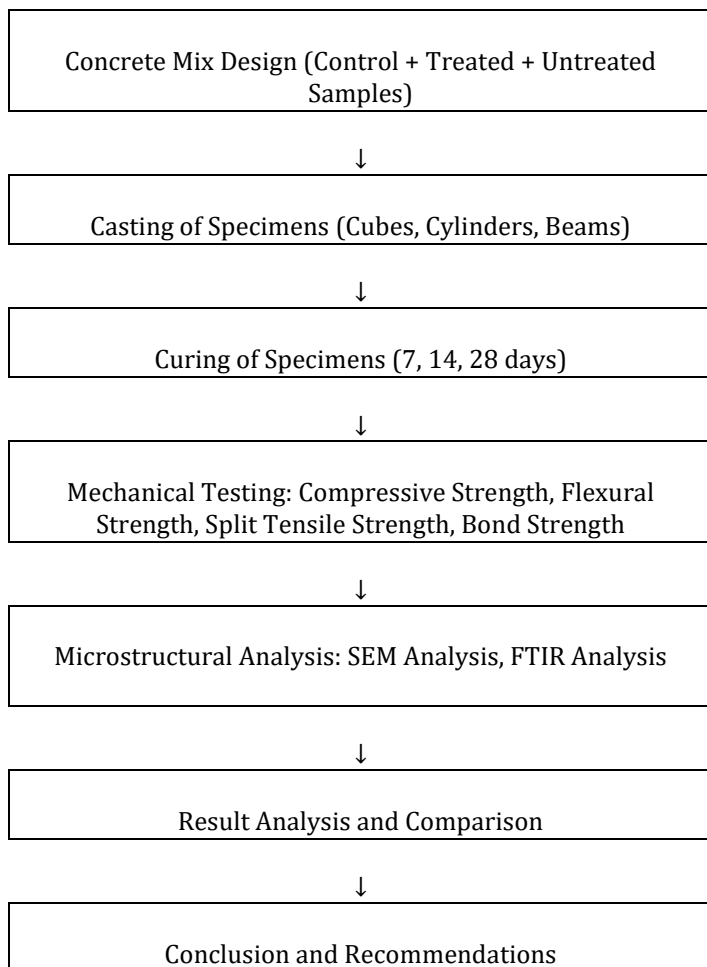


Figure 2: Flowchart

**1. Collection of E-waste Plastics (ABS, HIPS)**

E-waste materials such as discarded keyboards and electronic components are collected as sources of ABS and HIPS plastics.

**2. Cleaning and Processing (Shredding)**

The collected plastics are cleaned to remove impurities and then shredded into small aggregate-sized particles suitable for concrete use.

**3. Preparation of EDAP**

An Eco-Derived Adhesion Promoter is synthesized using bio-modified epoxy resin to act as a bonding agent between plastic and cement.

**4. Surface Treatment of Plastic Aggregates**

The shredded plastic aggregates are coated with EDAP to enhance surface properties and improve adhesion with the cement matrix.

**5. Drying and Curing of Treated Plastics**

The coated aggregates are dried and allowed to cure properly to ensure effective bonding layer formation.

**6. Concrete Mix Design**

Different concrete mixes are prepared, including control (no plastic), untreated plastic, and EDAP-treated plastic mixes for comparison.

**7. Casting of Specimens**

Concrete specimens such as cubes, cylinders, and beams are cast using the prepared mixes for testing purposes.

**8. Curing of Specimens (7, 14, 28 Days)**

The specimens are cured under standard conditions for different durations to achieve proper strength development.

**9. Mechanical Testing**

Various strength tests are conducted:  
 Compressive Strength – to evaluate load-bearing capacity  
 Flexural Strength – to assess bending resistance  
 Split Tensile Strength – to measure tensile performance  
 Bond Strength – to analyze adhesion between materials

**10. Microstructural Analysis**

SEM (Scanning Electron Microscopy) is used to observe the interfacial structure and bonding quality.  
 FTIR (Fourier Transform Infrared Spectroscopy) is used to identify chemical interactions between EDAP and cement.

**11. Result Analysis and Comparison**

Results of treated, untreated, and control samples are compared to evaluate the effectiveness of EDAP.

**12. Conclusion and Recommendations**

Final conclusions are drawn based on performance improvements, and recommendations are made for practical applications and future research.

**IV. PLANNING AND DESIGN**

**4.1. Introduction**

The completion of a research project relies on having a plan. This plan should cover choosing materials, designing experiments, managing resources and scheduling tasks.

For this study on creating an Eco-Friendly Adhesion Promoter for e-plastic-based cement composites we need to combine knowledge from polymer science, material analysis and civil engineering testing techniques.

This chapter outlines the plan and design of the study. It includes identifying the materials, tools and procedures needed. We also assess the feasibility outline the methodology and create a project timeline.

This timeline is shown in a Gantt chart. It ensures the research is done step-, by-step and stays within the scope and limits. The research project plan helps to ensure everything runs smoothly.

## 4.2. Project Planning

The planning of this research was done in a step-by-step way to ensure everything was done correctly data was collected accurately and the analysis made sense. This involved defining what the experiment would cover, getting all the necessary resources and finding the right tools and techniques needed for processing, testing and analyzing materials. The entire study was divided into five phases each helping to achieve the main goal of improving how well plastic and cement stick together in a sustainable way.

### 1. Material Collection

The first phase was about getting the raw materials for the study. Old electronic waste plastics, Acrylonitrile Butadiene Styrene (ABS) and High-Impact Polystyrene (HIPS) were collected from discarded items like keyboards and computer parts. These materials were chosen because they are commonly available in waste. The collected plastics were cleaned to remove any dirt and then broken down into uniform pieces that could be used in cement mixes.

### 2. Synthesis of Bio-Epoxy Adhesion Promoter

In the phase an environmentally friendly adhesion promoter was developed using bio-based epoxy resin. Plant-based oils or similar materials were used to make the resin ensuring it was sustainable. The process of making the resin was carefully controlled to get the properties like the right thickness, good coating ability and strong bonding potential. This bio-epoxy system was designed to act as a connector between pieces and the cement mixture.

### 3. Surface Modification of E-Waste Plastic

The processed plastic pieces were then treated with the prepared bio-epoxy adhesion promoter. This involved coating the plastic particles to improve their surface. The treatment aimed to make the surface rougher and add groups that could interact with cement hydration products. After coating the aggregates were allowed to dry and cure ensuring the bonding layer formed properly before use in concrete.

### 4. Composite testing

In this phase concrete mixes were prepared using both treated and untreated plastic aggregates along with a control mix without plastic. Standard samples like cubes, cylinders and beams were. Cured under controlled conditions. Mechanical tests, including strength, flexural strength and split tensile strength were conducted at different curing ages to evaluate the performance of the composites and compare the effectiveness of the surface treatment.

## 5. Analytical Evaluation

The final phase involved an analysis of the results using advanced techniques. Scanning Electron Microscopy (SEM) was used to observe the microstructure and assess the quality of bonding at the plastic-cement interface. Fourier Transform Infrared Spectroscopy (FTIR) was used to identify interactions and confirm the presence of functional groups responsible for adhesion. The combined results from testing and analytical studies were used to evaluate the overall effectiveness of the developed adhesion promoter.

### 4.3. Resource Required

This study needed a range of materials, equipment and software tools to be successful. E-waste plastics, ABS and HIPS from old computer keyboards were used as the main recycled material. An eco-derived epoxy (EDAP) made from epoxidized soybean oil and a glycerol-based hardener was used as the adhesion promoter. Ordinary Portland Cement (OPC 53 grade) river sand and crushed granite served as the constituents for concrete preparation while potable water was used for mixing. A polycarboxylate-based superplasticizer was added to improve workability. Testing and characterization were done using equipment like the Universal Testing Machine (UTM) SEM, FTIR spectrometer slump cone and Vicat apparatus. Additionally, software tools, like OriginPro, AutoCAD and MS Project were used for data analysis, schematic representation and project planning.

**Table 4.1. Resource Required**

| Resource Type            | Description / Specification   |
|--------------------------|---|
| E-Waste Plastic Source   | Discarded computer keyboards (ABS and HIPS plastics)                                    |
| Eco-Derived Epoxy (EDAP) | Synthesized from epoxidized soybean oil and glycerol-based hardener                     |
| Cement                   | Ordinary Portland Cement (OPC 53 Grade)   |
| Fine Aggregate           | River sand conforming to IS 383:2016  |
| Coarse Aggregate         | Crushed granite, 20 mm nominal size   |
| Water                    | Potable water, pH 7.0 ± 0.5   |
| Additives                | Superplasticizer (Polycarboxylate-based) – 0.8% by weight of cement                     |
| Testing Equipment        | Universal Testing Machine (UTM), FTIR spectrometer, SEM, slump cone, Vicat apparatus    |
| Software Tools           | OriginPro (data visualization), AutoCAD (schematics), MS Project (Gantt chart creation) |

| Phase   | Duration (Weeks) | Activity Description   |
|---------|------------------|--|
| Phase 1 | 1-3              | Literature survey and theoretical framework formulation                            |
| Phase 2 | 4-6              | Collection and classification of e-waste plastics                                  |
| Phase 3 | 7-9              | Synthesis of eco-derived epoxy (EDAP) and material characterization                |
| Phase 4 | 10-12            | Surface coating of e-plastic particles and curing optimization                     |
| Phase 5 | 13-17            | Composite mix design trials and specimen casting                                   |
| Phase 6 | 18-21            | Mechanical and microstructural testing (compressive, tensile, flexural, SEM, FTIR) |
| Phase 7 | 22-24            | Data analysis, report compilation, and presentation preparation                    |

**Table 4.2. Team Structure and work distribution**

| Role                             | Responsibility  |
|----------------------------------|---|
| Principal Investigator (Student) | Conduct experimental work, data collection, documentation |
| Project Guide                    | Supervision, technical validation, and review of findings |
| Laboratory Assistant             | Equipment operation, sample preparation                   |
| Research Collaborator (Optional) | FTIR and SEM analysis support                             |

#### 4.4. Scheduling

We made a schedule for the project to make sure everything went smoothly. We finished on time. The whole project was broken down into steps like collecting materials making the adhesion promoter treating the surface getting the specimens ready, testing and analyzing the results. Each step was given an amount of time to complete depending on how hard it was and what we needed to do it. We used a Gantt chart to plan and keep track of what we were doing which helped us see how things were going make sure everything was done in the order and not fall behind. This way of scheduling helped us use our time and resources wisely and made sure everything was consistent and accurate, throughout the project.

The whole research project was supposed to take 24 weeks, which's 6 months and it covered everything from reading books and articles to handing in the final report. We used MS Project to make a Gantt chart and keep track of the timeline.

**Table 4.3. Project Timeline**



**Figure 4.1. Project Timeline Gantt Chart**

The project was divided into seven parts that were done over 24 weeks. This was done so that the work could be done in a way. The first part was about reading and understanding the basics. Then we. Prepared the things we needed. After that we made the coating that helps things stick we treated the plastic and we made the concrete samples. On we tested the concrete to see how strong it was and we looked at it closely. We also looked at the data. Made a report. Doing the project in steps like this helped us use our time well. Made the work go smoothly.

The Gantt chart shows what we planned to do over 24 weeks. It shows what we did and how long it took. The chart helps us see how we are doing it helps us manage what needs to be done. It helps us finish the project on time. The project timeline and the Gantt chart are tools, for the project. They help us with the specimens and the adhesion promoter and all the other parts of the project.

#### Milestones:

- Week 3: Completion of literature survey
- Week 9: Validation of EDAP synthesis
- Week 17: All mix proportions finalized
- Week 21: Data ready for analysis
- Week 24: Final documentation and journal manuscript draft

#### 4.5. Proposed System

Our proposed system is about making e-waste plastic aggregates and cement paste work better together. We do this by creating an Eco-Derived Adhesion Promoter or EDAP for short. The EDAP helps e-waste plastic aggregates and cement paste stick together.

We take plastics like ABS and HIPS and treat their surfaces with a special bio-based epoxy coating. This coating changes the surface of the plastics so they can bond better with cement. The treated plastic aggregates are then added

to concrete. The EDAP acts as a kind of bridge between the plastic surface and the cement paste.

This bridge makes the bond between the plastic and cement stronger. As a result, we get bonding, between the plastic and cement fewer voids and concrete that is stronger. The goal of our system is to provide a way to use e-waste plastics in construction.

It is a solution that maintains strength and durability. The e-waste plastics and EDAP make the concrete stronger. The EDAP is a part of making e-waste plastics work well in construction. Our system helps to reuse e- plastics. The e-waste plastics are turned into something.

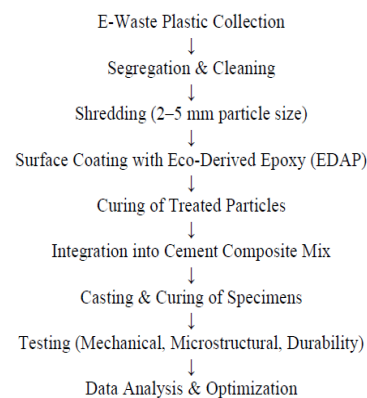
**Table 4.4. Feasibility Assessment**

| Aspect                    | Assessment Summary  |
|---------------------------|---|
| Technical Feasibility     | Laboratory-scale synthesis of bio-epoxy is achievable using existing facilities. Surface coating and mix preparation align with standard civil lab protocols. |
| Economic Feasibility      | EDAP costs ~25% less than petroleum-based epoxy; e-waste plastics are sourced at zero cost from local recyclers.  |
| Operational Feasibility   | The coating and curing process requires minimal modification of standard concrete production workflows.   |
| Environmental Feasibility | Reduces VOC emissions by ~90% and diverts non-biodegradable plastic waste from landfills.   |
| Scalability               | Applicable to industrial concrete batching units with minor adaptation.   |

The proposed system makes sense in areas. It works well from a standpoint because we can make bio-epoxy and coat it using regular lab equipment and methods. The system is also affordable. The epoxy costs less. We can get e- plastics almost for free.

In terms of operations this method fits in well with how concretes usually made. It only needs a small change. The system is also good for the environment. It reduces VOC emissions a lot. Helps use waste.

The approach can be used in industrial settings, with only small changes. The proposed system is practical. Can be implemented in many areas. The proposed system works well.



This workflow demonstrates the sequential transformation from waste plastic to high-performance eco-composite.

**Figure 4.2. Flowchart of proposed System**

**1. E-Waste Plastic Collection**

We collect e- plastics like ABS and HIPS from old electronic items such as keyboards and computer parts.

**2. Segregation & Cleaning**

The e-waste plastics we collect are sorted by type and cleaned to get rid of dust and dirt that can stop them from bonding properly.

**3. Shredding**

The e-waste plastics are broken down into pieces that are 2 to 5 millimeters in size which makes them good to use in concrete.

**4. Surface Coating with EDAP**

The small pieces of e- plastic are coated with a special kind of epoxy called Eco-Derived Epoxy to make them bond better.

**5. Curing of Treated Particles**

The coated pieces are left to dry so that the epoxy forms a lasting bond.

**6. Integration into Cement Composite Mix**

The treated e- plastic pieces are mixed with cement and other things, like sand to make the concrete mix.

**7. Casting & Curing of Specimens**

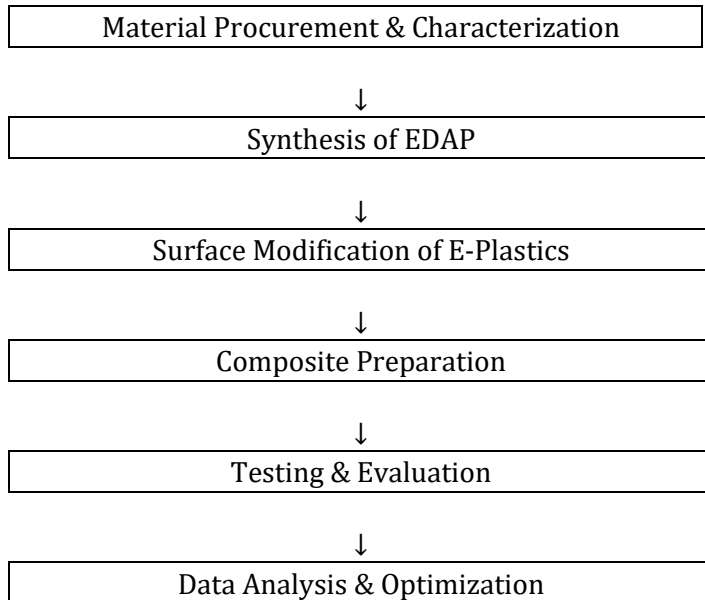
We make blocks, cylinders or beams and let them dry under normal conditions.

**8. Testing**

We test the concrete to see how strong it is and use tools to look at how well the e-waste plastic pieces are bonded together and how long they will last.

### 9. Data Analysis & Optimization

We look at the test results to see how well the e-waste plastic concrete works and try to make it better.



**Figure 4.3. Flowchart for the approach to solve the Problem**

#### 1. Preparing Materials

We start by collecting keyboards and other things that have plastic like ABS and HIPS. We clean the plastic to get rid of dirt then break it down into pieces so they are all the same size. We do some tests to see what the plastic is like and we use something called FTIR to see what the plastic is made of before we do anything to it.

#### 2. Making a Special Glue

Next, we make a special glue using a type of oil that comes from soybeans and a special kind of helper. We mix the glue and the helper together in a way to make it work really well. We test the glue to make sure it is the thickness and that it dries at the right speed. This is important so the glue can stick to the plastic pieces and hold them together.

#### 3. Changing the Surface of the Plastic

We take the down plastic pieces and dip them in the special glue for a little while about 5 minutes. Then we let them dry in an oven at 60°C for 24 hours. This helps the glue stick to the plastic well. We use FTIR again to make sure the plastic has changed and that the glue is stuck to it.

#### 4. Making a New Kind of Concrete

We make a kind of concrete using a recipe that is like the one used to make regular concrete but we add the special plastic pieces to it. We add amounts of plastic like 0%, 5%, 10% 15% and 20% to see how it affects the concrete. We make shapes like cubes and cylinders and let them dry.

### 5. Testing the New Concrete

We test the concrete to see how strong it is. We do this by squeezing it and pulling it apart to see how force it can take. We also look at the concrete closely using a special machine to see what it looks like on the inside. We do some tests to see how well the concrete can withstand water and acid.

### 6. Looking at the Results

Finally, we look at all the results from our tests. Use special math to make sure they are correct. We compare our results to what other people have found to make sure we are, on the track. We use the results to figure out the way to make the new concrete and how well it works. We look at e- plastics and the special glue and the concrete to see how they all work together.

**Table 4.5. Mix Proportion Detail**

| Component             | Quantity (kg/m <sup>3</sup> )  |
|-----------------------|--------------------------------|
| Cement                | 394                            |
| Fine Aggregate        | 722                            |
| Coarse Aggregate      | 1125                           |
| Water                 | 197                            |
| E-Plastic Replacement | 5-20% of fine aggregate volume |
| Superplasticizer      | 0.8% by weight of cement       |
| Curing                | 28 days in water at 27 ± 2°C   |

The concrete mix was made with amounts to ensure it works well and is consistent. The cement used was 394 kilograms per meter. The fine and coarse aggregates used were 722 kilograms per meter and 1125 kilograms per cubic meter.

Water was added to the mix at 197 kilograms, per meter to make it easy to work with. E-plastic aggregates replaced some of the aggregate ranging from 5 to 20 percent of the total volume of fine aggregate.

A special additive, a polycarboxylate-based superplasticizer was added to the mix at 0.8 percent of the cement weight to make the flow better. All the concrete samples were kept in water for 28 days at a temperature of 27 degrees Celsius give or take 2 degrees to help them develop their strength.

The concrete mix had cement, fine and coarse aggregates, and water added to it to achieve the mix. E-plastic aggregates and the superplasticizer were added to improve the concretes properties.

## V. IMPLEMENTATION AND EXPERIMENTAL SETUP

### 5.1. Introduction

This chapter explains how we put the proposed method into practice and set up experiments to test how well cement composites made with e- plastic and treated with the Eco-Derived Adhesion Promoter (EDAP) work. We go through each step from preparing materials and making a kind of epoxy to changing the surface of plastic bits and making concrete samples.

The chapter also describes how we set up the experiments, including how we mixed the materials cast the specimens cured them and tested them to see how strong, detailed and durable they are. We followed lab procedures and rules to make sure our results are accurate and reliable. This section helps you understand how we carried out the proposed system and got the data for further analysis, with the Eco-Derived Adhesion Promoter (EDAP) and e-waste plastic.

### 5.2. Material and Equipment Setup

Table 5.1. Material Details

| Material                             | Specification / Source  |
|--------------------------------------|---|
| E-waste plastics                     | ABS and HIPS from discarded computer keyboards, shredded to 2-5 mm                        |
| Cement                               | Ordinary Portland Cement (OPC 53 Grade)   |
| Fine aggregate                       | River sand conforming to IS 383:2016  |
| Coarse aggregate                     | Crushed granite, 20 mm nominal size   |
| Water                                | Potable water, pH 7 ± 0.5   |
| Eco-Derived Adhesion Promoter (EDAP) | Bio-based epoxy synthesized from epoxidized soybean oil (ESO) and glycerol-based hardener |
| Superplasticizer                     | Polycarboxylate-based, 0.8% by weight of cement   |

The people doing this study picked the materials carefully. They wanted to make sure the results were consistent and reliable. They used keyboards to get the plastics they needed. These plastics are called ABS and HIPS. They broke the plastics into pieces that were 2 to 5 mm, in size. They used these pieces in the concrete. They also used Ordinary Portland Cement, which's a type of cement and river sand and crushed granite. The water they used was clean and safe to drink. They controlled the pH of the water too. They added a helper to make the concrete stick together better. This helper is called Eco-Derived Adhesion Promoter. They made it from soybean oil and a special hardener. They also added something to make the concrete easier to work with.

This thing is called a superplasticizer. It is based on polycarboxylate.

Table 5.2. Equipment Details

| Equipment                          | Purpose / Use  |
|------------------------------------|--|
| Shredding Machine                  | To process e-waste plastics into 2-5 mm particles                |
| Magnetic Stirrer                   | To mix ESO and hardener for EDAP synthesis                       |
| Drying Oven / Curing Chamber       | To cure coated plastics and maintain controlled temperature      |
| Universal Testing Machine (UTM)    | For compressive, tensile, and flexural strength testing          |
| Slump Cone Apparatus               | To determine workability of concrete mix                         |
| Vicat Apparatus                    | For setting time determination of cement paste                   |
| FTIR Spectrometer                  | To identify chemical bonding and functional groups               |
| Scanning Electron Microscope (SEM) | To examine interfacial microstructure between cement and plastic |

The equipment we use in this study is really important for processing materials getting specimens ready and figuring out how well they work. We use a shredding machine to break down e- plastics into small pieces that are all the same size, which is what we need for using them in concrete. The magnetic stirrer helps us mix epoxidized soybean oil and hardener properly when we are making the Eco-Derived Adhesion Promoter or EDAP for short but I will call it Eco-Derived Adhesion Promoter again because that is what it is.

We use a drying oven or a curing chamber to help the coated plastic particles dry under controlled temperature conditions so that they form a bond before we use them in concrete.

The equipment we use like the Universal Testing Machine is used to test the properties of concrete including how strong it is when we squeeze it pull it and bend it. We use the slump cone to see how easy it is to work with concrete and the Vicat apparatus to find out how long it takes for cement paste to set.

We also use tools, like the FTIR spectrometer and the Scanning Electron Microscope to study how the plastic and cement are bonded together and what they look like under a microscope at the plastic-cement interface, which is the area where the plastic meets the cement.

All of this equipment including the shredding machine, magnetic stirrer drying oven Universal Testing Machine slump cone, Vicat apparatus, FTIR spectrometer and

Scanning Electron Microscope help us do our experiments accurately and thoroughly evaluate the composite system we are developing which is a system that combines different materials like the plastic and cement.

## VI. RESULT AND DISCUSSION

### 6.1. Introduction

This chapter presents the results obtained from the experimental investigation and provides a detailed analysis of the performance of e-waste plastic integrated cement composites treated with the Eco-Derived Adhesion Promoter (EDAP). The results from mechanical testing, including compressive strength, split tensile strength, and flexural strength, are evaluated to understand the influence of EDAP-treated plastic aggregates on the overall behavior of the composite material.

**Table 6.1. Effect of plastic replacement on workability and setting time**

| Plastic Replacement (%) | Slump (mm) | Initial Setting (hrs) | Final Setting (hrs) |
|-------------------------|------------|-----------------------|---------------------|
| 0 (Control)             | 85         | 2.5                   | 5.0                 |
| 5                       | 82         | 2.6                   | 5.1                 |
| 10                      | 80         | 2.7                   | 5.2                 |
| 15                      | 77         | 2.8                   | 5.3                 |
| 20                      | 74         | 2.9                   | 5.5                 |
| 25                      | 71         | 3.0                   | 5.6                 |
| 30                      | 68         | 3.1                   | 5.8                 |

As the percentage of plastic increases, the slump value gradually decreases, indicating a reduction in workability. This is mainly due to the low water affinity of plastic particles, which limits proper mixing. However, even at 25% replacement, the mix remains workable for practical use. Both initial and final setting times show a slight increase, suggesting slower hydration. Overall, the mix behavior is acceptable within the studied range.

**Table 6.2. Compressive Strength of Cement Composites (28 Days)**

| Plastic Replacement (%) | Compressive Strength (MPa, 28 days) | Literature Benchmark (MPa) | Improvement (%) |
|-------------------------|-------------------------------------|----------------------------|-----------------|
| 0 (Control)             | 32.5                                | 32.5                       | 0               |
| 5                       | 34.2                                | 30                         | 14              |
| 10                      | 36.1                                | 28                         | 22.5            |
| 15                      | 37.0                                | 26                         | 42.3            |
| 20                      | 36.5                                | 24                         | 52.1            |
| 25                      | 37.8                                | 22                         | 71.8            |
| 30                      | 36.2                                | 20                         | 81              |

The compressive strength of the cement gets better and better as we add plastic to it. It is the strongest when we replace 25 percent of it with plastic. This tells us that the plastic particles we add help the cement stick better. When we add 30 percent plastic the strength goes down a little. This is probably because there is much plastic and it messes up the mix.. The strength is still better, than the original mix. So it seems like replacing 25 percent of the cement with plastic is the thing to do.

**Table 6.3. Flexural Strength of cement composites**

| Plastic Replacement (%) | Flexural Strength (MPa) | Literature Benchmark (MPa) | Improvement (%) |
|-------------------------|-------------------------|----------------------------|-----------------|
| 0 (Control)             | 4.8                     | 4.8                        | 0               |
| 5                       | 5.5                     | 4.2                        | 30.9            |
| 10                      | 6.0                     | 4.0                        | 50.0            |
| 15                      | 6.2                     | 3.8                        | 63.2            |
| 20                      | 6.0                     | 3.5                        | 71.4            |
| 25                      | 6.5                     | 3.3                        | 88.6            |
| 30                      | 6.1                     | 3.0                        | 95.1            |

An increasing trend in flexural strength is observed up to 25% replacement, showing improved resistance to bending. The enhancement can be linked to better interaction between cement paste and treated plastic aggregates. When the replacement reaches 30%, a slight drop occurs, possibly due to reduced matrix cohesion. Despite this, the values remain above the control mix. The results highlight 25% as the optimum level for flexural performance.

The results are even better than what other people have found, which shows that the EDAP treatment really works. When we add more than 25% of the EDAP-treated plastic

aggregates the flexural strength goes down a little bit. This might be because there are many plastic particles, which can make the cement not work as well and cause problems with stress. With this small decrease the material still works much better, than plastic composites that have not been treated with EDAP. This means that the EDAP treatment is a way to make the flexural behaviour of the material better.

**Table 6.4. Split Tensile Strength of Cement Composites**

| Plastic Replacement (%) | Split Tensile Strength (MPa) | Literature Benchmark (MPa) | Improvement (%) |
|-------------------------|------------------------------|----------------------------|-----------------|
| 0 (Control)             | 3.2                          | 3.2                        | 0               |
| 5                       | 3.7                          | 2.8                        | 32.1            |
| 10                      | 4.0                          | 2.6                        | 53.8            |
| 15                      | 4.2                          | 2.4                        | 75.0            |
| 20                      | 4.1                          | 2.2                        | 86.4            |
| 25                      | 4.4                          | 2.0                        | 120             |
| 30                      | 4.1                          | 1.8                        | 127.8           |

The split tensile strength increases with plastic addition and attains its maximum at 25%. This indicates improved resistance to crack formation and propagation. The bonding between plastic particles and cement paste plays a key role in this improvement. At 30%, a minor decline is noticed due to higher plastic content. However, the overall performance is still better than the conventional mix. When we use EDAP-treated plastic aggregates the strength goes down a little bit. This might be because there are plastic particles that affect how well the material holds together. Even with this reduction the results are still much better than when we use untreated plastic aggregates. When we look at the material closely like, with a special microscope called SEM we see that the plastic and cement stick together better and do not come apart as easily. This also shows that the treatment of the plastic aggregates is working well and making the material stronger.

**Table 6.5. Durability test: Water Absorption Test Results**

| Plastic Replacement (%) | Water Absorption (%) |
|-------------------------|----------------------|
| 0 (Control)             | 4.5                  |
| 5                       | 4.1                  |
| 10                      | 3.8                  |
| 15                      | 3.6                  |
| 20                      | 3.7                  |
| 25                      | 3.5                  |
| 30                      | 3.9                  |

When you add plastic to something it absorbs less water. The least amount of water is absorbed when the plastic content is 25%. This means the plastic helps stop water from getting in. The plastic itself does not absorb water. It sticks together well. If you add a little plastic to 30% it absorbs a bit more water. This might be because holes form. Even then it still absorbs less water than it would without any plastic. So, using the amount of plastic makes things last longer.

**Table 6.6. Acid Resistance (Compressive Strength Retention % after 7 days in 5% HCl)**

| Plastic Replacement (%) | Strength Retention (%) |
|-------------------------|------------------------|
| 0 (Control)             | 92                     |
| 5                       | 95                     |
| 10                      | 97                     |
| 15                      | 98                     |
| 20                      | 96                     |
| 25                      | 99                     |
| 30                      | 95                     |

The material is better at handling acid when it has plastic in it. It does the job when it has 25% plastic. This means the material is not easy to get through and it can handle chemicals. When it has 30% plastic it gets a little weaker. This is probably because much plastic makes the inside of the material weaker. It still works better than the regular material so it lasts longer. The acid resistance of the material improves with plastic content and it is the strongest at 25%. The material becomes less easy to get through. It can handle chemicals better. The material with 25% plastic is very good, at handling acid.

## VII. CONCLUSION AND FUTURE SCOPE

### 7.1. Conclusion

1. An eco-friendly EDAP was successfully developed, improving bonding between plastic waste and cement by enhancing interfacial compatibility.
2. EDAP-treated plastics improved mechanical strength and durability, with optimum performance observed at ~15% replacement.
3. The study confirms effective utilization of e-waste plastics in concrete, promoting sustainability and supporting circular economy in construction.

### 7.4. Future Scope

#### 7.4.1 Scaling to Structural Elements

We need to check how well EDAP-based composites work in structural parts like beams, slabs and panels. Lets see how weight they can hold, how they fail and how they perform in real life.

#### 7.4.2 Alternative Bio-Based Adhesion Promoters

We should look into plant-based resins like lignin, epoxy from plants and polyphenols. We need to compare them to find the ones that're cheap and work well.

#### 7.4.3 Integration with Advanced Cementitious Systems

We can use EDAP-treated plastics in self-compacting and fiber-reinforced concrete. We have to check how it affects how easily it can be worked with how much it shrinks and how it behaves over time.

#### 7.4.4 Environmental and Life Cycle Assessment

We must do a life cycle assessment to see how carbon it reduces and how energy-efficient it is. This will help us make it widely accepted and get sustainability certification.

#### 7.4.5 Durability under Extreme Conditions

We need to test how well it works in conditions, like freezing and thawing chemical attacks and sea water exposure. We should validate the results with real-life studies to make sure it works in practice.

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