BACHELOR OF ENGINEERING IN

CIVIL ENGINEERING

PROJECT REPORT

INVESTIGATION OF POTENTIAL OF SMART COST-EFFECTIVE INFILL PANELS USING PLASTIC WASTE AND FLY ASH

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This is to certify that the Final Year Project entitled

INVESTIGATION OF POTENTIAL OF SMART COST-EFFECTIVE INFILL PANELS USING PLASTIC WASTE AND FLY ASH

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Has been accepted towards the partial fulfilment of the requirement for
BE Civil Engineering Degree

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Dedication

This is dedicated to our parents and our teachers without their support this effort would never have been completed.

Acknowledgements

Praise be to Almighty Allah, the most merciful and most beneficent, with His gracious help this work has been accomplished successfully.

We thank our parents for all their prayers and support which helped us throughout our Civil Engineering Degree, and gave us the encouragement, motivation, and the inspiration to take on this project.

We would like to extend our sincere gratitude to our advisor Maj Dr Naeem Shahzad for the continuous support and motivation. His professional command and commendable guidance made this project possible and helped us achieve our goals.

We are obliged towards Military College of Engineering (MCE), our Alma mater, for providing us the best of resources and atmosphere for completing our project work.

This is a beginning of a long road, and we hope to achieve success in all our future endeavors with the help of Almighty Allah.

بسم الله الرحمن الرحيم

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Chapter 1

INTRODUCTION AND HISTORICAL BACKGROUND

1.1 General

The supporting wall that seals the perimeter of a building made with a three-dimensional framework structure is known as the infill wall (generally made of steel or reinforced concrete). Since the infill wall helps to divide inner and outside space and fills the boxes of the outer frames, the structural frame ensures the bearing function. The infill wall's special static ability to support its own weight makes it stand out. An exterior, vertical, opaque type of closure is the infill wall. The infill wall is distinct from both the load-bearing and non-load-bearing partition that divides two internal spaces in comparison to other types of walls. The latter also performs static tasks in addition to the hygro-thermal and acoustical duties carried out by the infill wall.

In many nations, especially in reinforced concrete frame constructions, masonry infill walls and to some extent veneer walls are frequently used. In fact, using brick infill walls provides a cost-effective and long-lasting option. They are simple to construct, aesthetically pleasing, and have excellent cost-performance ratios.

Today, clay units, aggregate concrete units (dense and lightweight aggregate), and autoclaved aerated concrete units are utilised to create masonry enclosures and partition walls. Industry has also recently tried to introduce wood concrete blocks. Partition walls, made with both vertically and horizontally perforated clay blocks, represent two-thirds of the corresponding market.

A type of cladding constructed in between a building's structural parts is known as infill panel walls. The cladding system is supported by the structural frame, and it separates the interior environment from the exterior environment. Other types of cladding panels are affixed to the exterior of the frame, whereas infill walling is fixed between framework sections.

1.2 Plastic Waste as Sustainable Material

Only 9% of the 400 million tonnes of plastic produced worldwide each year is recycled. Both at the depths of our oceans and on the summits of our highest mountains, plastic that does not decompose is a big contributor to climate change. According to scientific predictions, the amount of plastic trash in our oceans will triple over the next two decades.

As a result of this awareness, individuals all over the world are coming up with creative ways to remove plastic debris from their surroundings and use it. People are turning plastic waste into building materials and using them to create homes, schools, community centres, and storage facilities anywhere from Canada to Colombia to Ivory Coast.

The ideal material for construction is plastic. It is readily available, inexpensive to produce as building materials, and simple to mould. The substance is strong, waterproof, and insulating, making it appropriate for use in construction in a variety of climates.

Compared to other building materials, it uses a lot less heat or power. Glass and aluminium have substantially higher melting temperatures than most polymers, which typically melt at roughly 200 °C.

The world should reexamine its connection with plastic and discover sustainable ways to use plastic garbage. One efficient method for doing this is construction. You are placing the plastic into a fixed application in addition to removing it from the environment. It won't be used again.

Whether it's PVC windows, plastic foam insulation, or plastic water pipes, plastics have a significant role to play in sustainable building.460 million tonnes of CO_2 per year might be saved if all buildings in Europe were constructed to the highest standards. Plastic foams are very affordable and have great insulating qualities.

Energy can be conserved by using EPS, PU, or melamine formaldehyde foam insulation. Over the course of a building's life of 25 years, 1 kg of oil used to create EPS will save the equivalent of 75 kg of oil for heating.

Since they are lightweight and need less energy to create than concrete or iron pipes, plastic pipes save building industry emissions and transportation expenses. Additionally, the installation of new plastic pipes prevents leaks and saves a lot of water, which reduces the amount of energy needed to process and pump the water.

1.3 Plastic In Construction Engineering

a. Concrete and cement

The possibility of incorporating different materials into cementitious composites during the mixing process has made it possible to do so. The cementitious composite contains aggregate and a variety of different waste products as a binder. Slag can be utilised in geopolymer mixes only as a binder. Similar to waste materials, cementitious composites can use pozzolans and fillers such as rice husk ash, cement kiln dust, recycled concrete, stone dust, and recycled concrete, etc. Due to its stability and hardness, mechanically recycled PW can be used as fillers and aggregates in cementitious composites.

The use of PW as aggregate in cementitious amalgams opens up a way to lessen the burden that mining for natural aggregates has on the environment. Additionally, due to PW's light weight, it can be used as a feasible component in the creation of a lightweight cementitious composite. This composite is useful for a variety of structural works since it reduces deadweight. However, research revealed that plastics shouldn't be utilised in nonstructural concrete because they have been labelled as an impurity in cementitious mixtures, highlighting their potential to reduce the strength of concrete.

When PW is shred, it can also be used as fibres in cementitious composites, however the properties of the resulting composite are different than when it is used as aggregate. For instance, it has been discovered that using PW as fibre lowers the slump of the cementitious mixture, whilst using it as aggregate results in a slump increase. When PW is employed as fibre at doses exceeding 0.3 percent, it was also shown that the air % of cementitious compound increased. The inclusion of PW materials in cementitious mixtures has led to an increase in air content, which can be credited to the potential introduction of cavities into the matrix as well as the impact of residual surfactant on the surface.It has been discovered that using PW as a fibre in cementitious composites has no negative effects on the compressive strength in standings of mechanical properties.

In light of the permeability characteristics of cementitious composites containing PW, it has been discovered that adding PW as a fibre increases the permeability of the composites. On the plus side, the use of PW as a fibre increased the composite's abrasion resistance. Similar to this, it has been discovered that using recycled plastic as fibres in cementitious composites might reduce plastic shrinkage. Recycled plastics can also be used to significantly improve the thermal characteristics of cement-based products. The low thermal conductivity of PW can be credited with its capacity to enhance the thermal characteristics of cement-based materials.

Few research have looked at using PW as a glue to create polymer concrete that has enhanced qualities in adding to the usage of PW in cementitious composite that was previously discussed. PET, a PW type primarily utilised as a wrapping material, is the PW type used as a binder.

"Transesterification" is the procedure used to turn the PW into a binder. Glycols and dibasic acid are used in the transesterification process to transform PW into unsaturated polyester resin. The produced resin is combined with particles to create mortar or concrete.

b. Insulation material

Materials for insulation are important architectural components. Alternative materials must now be used as insulation because of the economic and environmental problems with conventional insulation materials. Recycled plastic is one of the most environmentally friendly materials that might be employed. PW in particular can be used as padding throughout the construction procedure in the form of expanded polystyrene (EPS).

c. Walls and bricks

PW can likewise be used to build walls instead of more typical wood, brick, or block construction. Recycled plastic is put into heated moulds to produce blocks, which are then pressed together to create these plastic walls. It is important to note that while these kinds of walls are appropriate for wall building works like divider walls, they cannot be used for load-bearing purposes.

Waste plastic bottles can be organised in a comparable pattern to blocks and used for walls instead of traditional bricks. The trash bottles are joined together by slipping each bottle's bottleneck into the base of an additional bottle. Plastic bricks, like plastic walls, can be utilised as a limited amount of structural material, despite having a low strength. Similar to how LDPE-based plastic waste can be used in building.

It has been discovered that concrete that uses plastic wastes as a partial replacement for sand in the fine aggregate elements produces good resistance to impact loading.When plastic components made up 20 percent of the concrete, the impact increased by 39 percent, but the resulting mixture produced concrete that was stronger, more energy-absorbing, and performed well under impact loading.

1.4 Potential The Prospect of Plastic Recycling as a Source of Income

The following methods can be used to generate potential revenue as a result of using PW for various construction applications:

a. **A decrease in the cost of waste management**. Municipalities spend a significant amount of money each year on the expensive operations of incineration and landfilling. Instead of putting them in landfills or burning them, it may be able to use PW for building, which would save a tonne of money and provide funds for other crucial municipal tasks.

b. **Value addition**. The potential use of PW will give previously regarded waste products a monetary worth. The financial worth increase to these materials will provide an additional cause of income for parties involved in salvaging waste materials and plastics manufacturers.

c. **A decrease in energy prices**. Buildings' energy efficiency will increase with the usage of PW as an insulation material, lowering their overall operating expenses.

d. **Lower transportation cost**. If RPW is practical for use in construction, it will open up a market for the use of locally produced plastic waste, bringing down the high cost of shipping of building supplies. For instance, the local accessibility of RPW that may be employed as aggregates in the cementitious composite will minimise the need for long hauls and the related transportation costs. Aside from the financial costs associated with carbon emissions, reducing or eliminating the need to transport particular building materials will lessen the harmful pollutants that is released into the environment during transportation.

e. **Cheaper building supplies**. PW are thought to be wastes and hence have little or no value. Utilizing such materials in construction will therefore eradicate the cost of using traditional building resources and lower the general cost of construction.

1.5 Plastic Waste Future Perspective

Plastics are widely used in modern culture, and as a result, garbage will inevitably result from their use. Therefore, its practice for diverse construction works is a potential choice for appropriately managing these plastic wastes while improving the sustainability of the environment. The utilisation of various recovered plastic debris for construction applications has been fully covered in this overview of recent research. Based on this overview, the following conclusions can be drawn:

a. The use of PW in construction applications will address the issues of decreasing deposits of raw materials and solid waste management. Additionally, the circular economy sustainability trend is supported by the usage of PW in various construction applications.

b. In contrast to temporary uses, such as recycling into new goods, which result in waste in a short amount of time, using PW for building purposes opens a channel for using these wastes in long-term applications.

c. PW is a plausible alternative for every component in cementitious composites due to its potential usage as a binder, aggregate, and fibre, with only marginally unacceptable negative effects on the working of the resulting compound.

d. Using PW for different construction products would result in different revenue creation.

With the development of investigative and technical advancement, there is still a considerable possibility of its usage despite the plentiful restrictions on the working of plastic wastes for construction purposes outlined previously. Additionally, it is predicted that the government and the organisation responsible for regulating the building industry would propose legislation that will promote the use of recycled wastes like RPW for construction determinations.

1.6 Functions of Infill Panel Walls

a. They sustain themselves between the structural framing components.

b. They offer weather resistance.

c. They offer sound and heat insulation.

d. The offer resistance to fire.

e. They offer enough windows and openings for natural ventilation.

f. They are able to account for differences in movement between themselves and the frame.

g. They don't contain any toxic asbestos

h. They conserve energy

1.7 Infill panel Types

Infill panel walls have historically been constructed using brick/masonry or timber, but these materials require more time to complete than more recent options, which have mostly been supplanted by lightweight steel C-sections that span between floors and around apertures.

a. **Brick Infill Panels**. To start clay bricks or solid or cavity-shaped concrete blocks can be used to construct them. The same hollow wall and solid wall building techniques can be used to make infill panel walls. They can be fastened to columns with wall ties or anchor slots that are spaced 300 mm apart.

b. **Concrete Infill Panels**. These are typically large precast concrete panels having a height of one level and a width specified by the frame spacing. Both the top and the bottom can sustain them. Integral panels may be clad with different materials, typically stone. The crane lifting capacity and transit restrictions often place limits on the largest panel size..

c. **Timber Infill Panels**. To bridge 2.4–3.6 m between floors, timber sections are normally 90–140 mm deep, cut to length, and installed at 400–600 mm intervals. Timber lacks strength and cannot be utilised in tall portions or walls with large apertures for doors or windows, which is a drawback of utilising wood in place of steel.

1.8 **Lightweight Steel Infill Panels**. Lightweight steel is commonly used in multi-storey framed construction for the infill panel walls that support the exterior cladding. The panels, which might include architectural elements like huge windows, parapets, and other features, are fixed between the frame's structural horizontal and vertical parts.

The panels are quick and simple to install and are lightweight. Depending on the height of the façade wall and the wind loads, several steel section sizes and thicknesses might be used. Typically, galvanised steel strip with a thickness of 1.2 to 3.2 mm is used to cold roll shape C-sections and U-sections with a depth of 75 to 100 mm. Large apertures can be covered by pairs of C-sections, which are normally spaced 400 or 600 mm apart.

1.9 Research Hypothesis

For this research we have kept two in mind:

a. Use of recycled LDPE waste aggregate and fly ash in concrete with a view to reduce its cost and weight by replacing normal coarse aggregate and fine aggregate.

b. Using recycled LDPE waste aggregate and fly ash for constructing an infill panel and comparing its properties with normal brick wall and EPS smart panel.

1.10 Research Objectives

To verify the above hypothesis, the key emphasis of this research is to develop an infill panel which is light weight and cost effective. A theoretical write-up will also be made to justify the experimental results and to make path for further development of this new panel. Following objectives together with the approach given below are to be to be achieved in the project.

a. **Objective 1**. Identify the effects on reduction of weight and cost of concrete when replacing coarse and fine aggregates with LDPE aggregate and fly ash in different percentages. Calculations of surface density and cost per square foot of wall were made for comparison with normal brick wall and EPS smart panel.

b. **Objective 2**. Identify the effects on properties of infill panel when replacing coarse and fine aggregates with LDPE aggregate and fly ash in different percentages and comparing its properties with 4.5 inch brick wall and EPS smart panel. Relevant ASTM prescribed tests were carried out in detail to study the properties of concrete with understanding of replacing normal aggregates with LDPE aggregate and using fly ash as a filler material in concrete.

Chapter 2

LITERATURE REVIEW

2.1 Ghernouti et al. (2014)

The study by Ghernouti et al. (2014) shows partially replacing waste plastic bag with fine aggregate in concrete. Plastic sand was obtained after melting plastic bags in extrusion plant folled by cooling and crushing of plastic sand with finess modulus of 4.7. Plastic bag waste was added in place of fine aggregate with different proportions of 10,20,30 and 40%, while proportion of other ingredients of concrete was not changed. It was observed that with increased plastic content workability of concrete increased, bulk density decreased, and 28 days flexural and compressive strengths reduced. Volume of the voids was increased by plastic waste which in turn decreased the density of concrete and reducing speed of sound in concrete. Reduction of strength was main concern but still 10% to 20% replacing of fine aggregate with plastic was recommended. Neither the application of admixtures to address the decreased strength of concrete was taken into account nor any cost analysis was done in the study.

2.2 Ramesh et al. (2012)

Ramesh et al. (2012) make use of waste plastic of reduced density (polyethylene) as substitute of coarse aggregate to determine its possible application in construction industry. Various concrete mixtures were made with changing proportions (0%, 20%, 30% & 40%) of reuseable plastic aggregate acquired by heat treatment of plastic waste (160 to 200 centigrade) in plastic granular recycling machine. A concrete mixture design with proportion of 1:1.5:3 was utilized with 0.5 water/cement ratio having differing proportions of plastic aggregate substituting crushed stone. Results showed reduction of compressive strength clearly, with rising amount of plastic aggregate (strength upto 80% was achieved by 30%

plastic addition). The research underlines the likely application of plastic aggregate in light weight aggregate. Their research was focused on compressive strength of concrete with no importance given to flexural properties, fire resistance, insulation/heat preservation and acoustic performance of concrete.

2.3 Belmokaddem et al. (2020)

Study done by Belmokaddem et al. (2020) in which they compared and evaluated the effect of substituting coarse and fine aggregate with three different plastic wastes. These wastes included (high-density polyethylene HDPE, polypropylene PP, and polyvinylchloride PVC). Various quantities of aggregates were replaced with plastic aggregate having same volume . The results indicated that by decreasing the density plastic has positive outcome. Furthermore, low dynamic modulus was indicated by concrete having 75% polyethylene aggregate. A composite material was formed by using plastic in concrete having noteworthy sound insulation characteristics.

2.4 EPS Solutions Pakistan (Pvt) Ltd

stands as a pioneer for being the first entity to locally manufacture and introduce EPS Smart Panel Technology to Pakistan's construction sector. EPS (Expanded Polystyrene) Smart Panel is composed of an exterior surface and interior core filling, to form a non-load-bearing light-weight composite wall panel. The exterior surface on both sides are calcium silicate boards / cement boards and the middle core is filled with EPS beads & cement, fly ash etc. EPS is a versatile durable material that offers excellent insulation properties. The wall material is completely dry work, fabricated construction. Smart Panels are 100% free of harmful and A grade radioactive substances. They are reusable and have no construction waste. EPS is classified as 'non-combustible' when tested in accordance with GB8624: Grade A1. Fire resistance rating is up to 240 Minutes against high temperatures of around 1000 degrees Celsius; Exposure of more than 04 hours for fire resistance test, Smart panels do not

emit any toxic gases. They are anti-pressure, anti-quake and have an impact strength 1.5 times stronger than a conventional block wall. Smart Panels offer excellent sound insulation, sound absorption and noise reduction functions. Sound insulation is ensured up to 40dB with 90mm thickness of the smart panels, which is 3 times higher than a traditional brick wall. Bulk density of a single Smart Panel is 600-700 Kg/Cu.m which is 5/1th of the traditional block wall. Specific gravity is smaller than 1, reducing the building structure & foundation cost. It carries High compressive and
flexural strength which makes it suitable for ultra-high and large span walls. The thermal conductivity of Smart Panel is 08 times better than a block wall. Smart Panels are thinner than standard block walls. Which increases building useable area.

2.5 Knowledge Gap

a. Plastic in hard form can be used as a replacement of coarse aggregate, thus reducing the weight of concrete

b. Light weight concrete can reduce the cost of construction.

c. Fly Ash also help in the reduction of weight of concrete as it was used in place of sand

d. More focus was given to the compressive strength of concrete containing plastic and less attention was given to other properties such as weight reduction, cost reduction.

e. A plastic with low specific gravity has great potentials in light weight concrete but was not comprehensively covered by any of the researcher.

f. Development of plastic is hazardous and environmental challenge, using in concrete can reduce this hazard.

Based on above literature work we reached to a conclusion that Plastic waste can be effectively use in concrete. Decrease in density and compressive strength was reported by all researchers. The area of focus of all the researchers was restricted to compressive strength and a wide gap is left for further research on other properties of concrete produce by using plastic wasted such as weight and cost reduction. Plastic waste material requires detail investigation on behavior of its various types in concrete.

Chapter 3

METHODOLOGY

The effort of this FYP is to carryout wide-ranging experiments to compare the properties of infill panels made out of recycled plastic waste and fly ash concrete with brick walls and EPS panel. Moreover, testing was carried out on samples of recycled plastic concrete to check its feasibility to be used in infill panels. For that purpose, various concrete samples were casted for various mix designs with variation of recycled LDPE plastic waste and fly ash replacing coarse aggregate and fine aggregate respectively in the mix and several tests were conducted.

3.1 Materials Used

a. Portland Cement. Portland cement is the composition of four basic compounds, tri calcium silicate (C_3S), di calcium silicate (C_2S), tri calcium aluminate (C_3A), and tetra calcium aluminoferrite (C_4AF). Dry process is used for the manufacturing of this cement these days. In this process, raw materials are first grinded and then fed at measured amounts into a rotary kiln. After then, they are passed into burning chamber where they amalgamate into small lumps or balls called clinkers. On the other hand, in wet process, a slurry of blend is introduced into the rotary kiln. The resulting clinker is first cooled and then grounded in two steps. A particular amount of gypsum (*i.e.*, 2 to 3% by mass of cement) is mixed between the first and the final grind to control the setting time of cement.

We used Askari Cement (Portland) for casting blocks, prisms, and cylinders in different concrete mixes with varying percentages of plastic and fly ash as replacement of coarse aggregate and fine aggregate respectively. Askari Cement is well renowned in Pakistan for its quality manufacturing. Characteristics of cement are shown below in Table.

Properties of Cement Used			
ser	**Characteristics**	**Value**	**Remarks**
1	Consistency	32.0%	-
2	Initial Setting Time	About 60 min	Not less than 30 min
3	Final Setting Time	About 270 min	Not greater than 600 min
4	Fineness	4.50%	Less than 10%
5	Specific Gravity	3.1	-

b. **Fine Aggregate**. Selection of Fine Aggregate is based upon the guidelines and values of AASHTO M6 and ASTM C33. Due to wide range of permitted values, fine aggregate was selected for concrete which suited well the requirements of the site. Many things were taken into consideration while selecting appropriate fine aggregate such as type of work to be done, mix richness and selection of maximum size of coarse aggregate etc.

Mardan and its surroundings was chosen by us as it was having good engineering properties. We are well aware of the strength, workability, and strong bond qualities of fine aggregates which plays a very important role. Properties of local sand are shown in Table.

Properties of Sand Used		
ser	**Characteristics**	**Value**
1	Specific Gravity	2.54
2	Water Absorption (%)	1.03 %
3	Fineness Modulus	2.63

c. **Coarse Aggregate**. Selection of Coarse Aggregate is based upon the guidelines and permitted values of AASHTO M80 and ASTM C33. Coarse aggregate for concrete was selected due to wide range permitted values. This selection was in accordance to the requirements of the site.

Mardan and its nearby areas were sorted out owing to having the better engineering properties. As we are well aware of the fact that coarse aggregate plays a pivotal role from strength, workability, and strong bond qualities pointof view. Pricing of concrete is highly effected by the maximum size of coarse aggregate. Characteristics are as under shown in Table 3.4.

Properties of Coarse Aggregate Used		
ser	**Characteristics**	**Value**
1	Type	Crush
2	Specific Gravity	2.6
3	Water Absorption	0.24 %
4	Crushing Value	20 %
5	Unit weight	98 lb/ft3

d. **Plastics Aggregate**. Plastics are one of the new materials which are introduced in the field of construction. It is widely used across the globe due to its low cost, extended durability, easy manufacturing, availability and innumerable colours. This industry is one of the fastest growing industries of the world. Plastic material can be modified and used in different forms depending upon the need. Many different types of plastics are available having low rigidity and high creep value in contrast to the other construction materials.

Recycling of Plastic and converting it into Coarse Aggregate: Waste plastics in the form of shopping bags was collected from surroundings. They were then washed and cleaned to remove any dirt and mud. The cleaned plastic was then moulded into desired sizes. Plastic waste aggregate was then sent to Plastic Recycling Granular container where it was heated at the temperature of 160 to 200oC. It was then cooled and cut into small pieces. The pieces of plastic slub were then treated in grinding mill where it was placed in basket of crushing machine. It was subsequently crushed into sizes ranging from 2mm to 5mm. To get rough aggregate, rough edge of cutter was used. Properties are shown in the table below.

Properties of Plastic Used		
ser	**Characteristics**	**Values**
1	Type	Granules
2	Specific Gravity	0.93
3	Water Absorption	0.5 %
4	% of Crushing Value	2
5	Unit weight	27 lb/ft3

d. **Fly Ash**. Fly ash is the finely divided residue that results from the combustion of pulverized coal and is transported from the combustion chamber by exhaust gases.

The composition of fly ash used was as per (ASTM 2011). (59.96% SIO_2, 14.02% Al_2O_3, 6.29% Fe_2O_3, 14.12% CaO, 2.84% SO_3, 0.41% MgO)

e. **Formica / Laminate**. Formica is a smooth and hard surface material used to make variety of laminated products such as tabletops,wallboards and other related prooducts. Special papers are infused with synthetic resins, like melamine which is then put through heat and pressure. About six sheets are bonded together to form a stiff and long lasting surface material which is 1/16 in (about 1 1/2 millimeters) thick. The top sheet is usually coloured and patterned whereas finish may be either polished or dull depending upon the use. Formica sheets are commonly bonded to plywood or other appropriate backing. Formica is resistant to boiling water, heat, food acids, alkalies and alcohol normally found at home and is easily cleaned. In order to withstand the heat, the product used at commercial level, such as in restaurants, consist of a very thin sheet of metal.

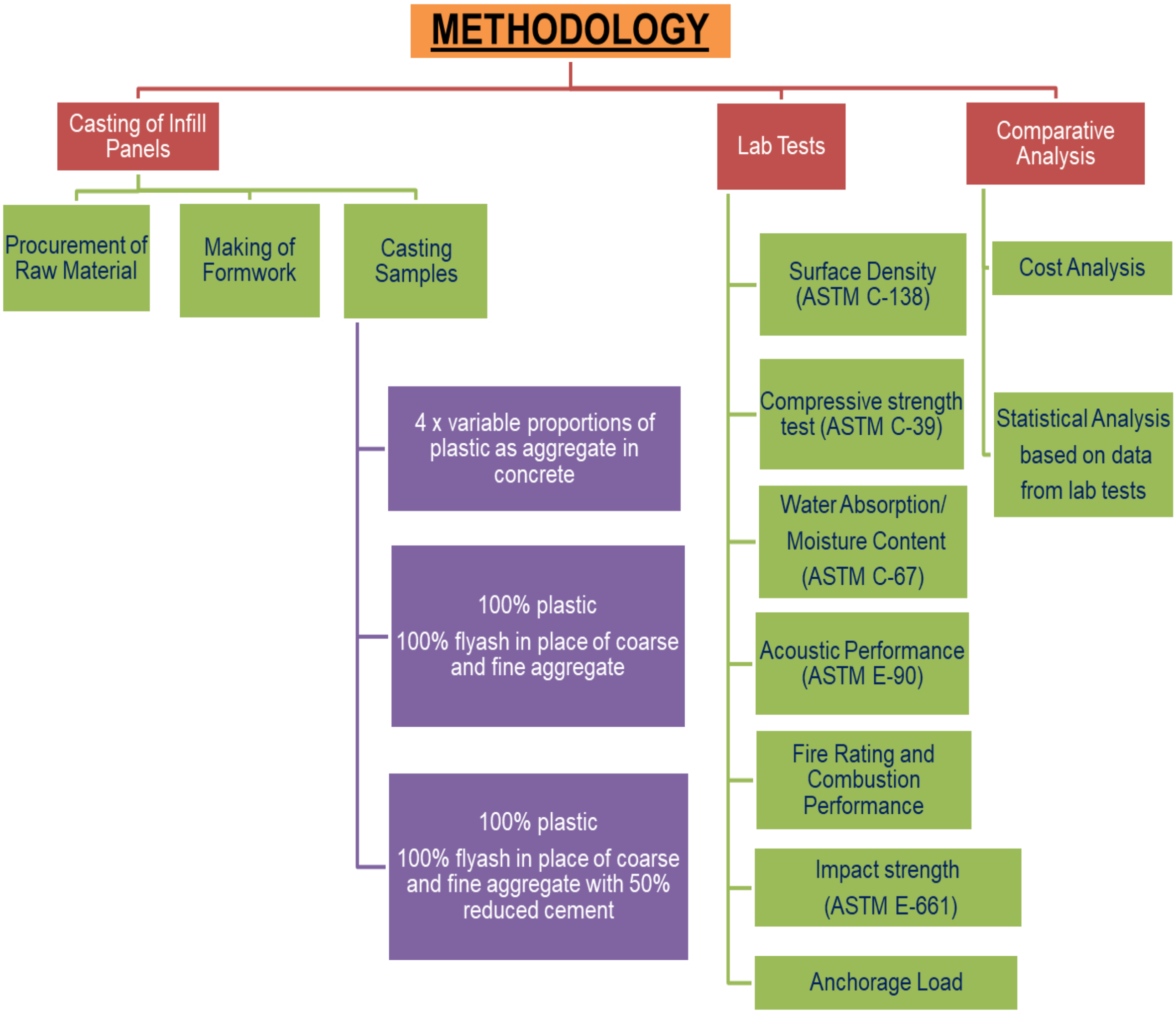
3.2 Mix Proportions

Precise blend of different materials in concrete is attained through correct proportioning of concrete mix. Correct proportioning of ingredients of concrete have direct bearing on cost, strength, cost, workability and durability. Finalizing the right amount of cement, aggregate, fly ash and water is a long process linking both art and science.

Keeping in view the requirements of our mix we reached to 1:1:1 (cement:plastic:flyash), after several trial mixes with a w/c ratio of 1. Limits of gradation of ASTM C33 were followed. We prepared our mix by replacing coarse aggregate with plastic aggregate at varying percentages of 30, 50, 80 and 100% with fine aggregate as sand. Then we made two more mixes by replacing 100% coarse aggregate and fine aggregate by plastic aggregate and fly ash respecticvely, in one of these mixes cement content was reduced by 50%. In total 6 mixes were prepared and tested for their feasibility to be used in infill panels.

3.3 <u>Casting of Samples and its Curing</u>

Conclusions can not be made about concrete short of proper testing as per ASTM standards. Compilation of results followed by recommendations can only be done based on tests carried out on samples. For testing we casted a 12” x 6” cylinder, a prism, three 4” x 4” cubes and a 6” x 3” cylinder for each mix using hand mixing and mixer machine at MCE concrete lab. submerged curing was ensured at for all samples for 28 days.


METHODOLOGY
Casting of Infill Panels
Procurement of Raw Material
Making of Formwork
Casting Samples
4 x variable proportions of plastic as aggregate in concrete
100% plastic
100% flyash in place of coarse and fine aggregate
100% plastic
100% flyash in place of coarse and fine aggregate with 50% reduced cement
Lab Tests
Surface Density (ASTM C-138)
Compressive strength test (ASTM C-39)
Water Absorption/ Moisture Content (ASTM C-67)
Acoustic Performance (ASTM E-90)
Fire Rating and Combustion Performance
Impact strength (ASTM E-661)
Anchorage Load
Comparative Analysis
Cost Analysis
Statistical Analysis based on data from lab tests

3.4 <u>Tests Conducted</u>

Tests that were conducted are as tabulated below:

Ser. No.	Property	Units
1	Surface Density (ASTM C-138)	(Kg/in3)
2	Compressive Strength (ASTM C39)	(psi)
3	Absorption/ Moisture content (ASTM C-67)	%
	a. Air Dry	(Kg)
	b. Saturated Surface Dry	(Kg)
	c. Oven Dried	(Kg)
4	Combustion Performance	-
5	Fire Rating Partition	-
6	Anchorage Load	-
7	Impact Strength (ASTM E-661)	-
8	Acoustic Performance	-

e. <u>Surface Density</u>

The surface density has been calculated as per ASTM-138. The unit weight of the composite sample was divided by its volume to get the surface density.

f. <u>Compressive Strength</u>

It is a type of mechanical test used to determine the ultimate sum of compressive load that a material can take before fracturing. Typically used samples are cylinders or cubes, the sample is compressed between the plates of compression-testing machine by applying load gradually as per ASTM C39 . 3 similar samples were tested after curing and average strength was noted.

g. **Water Absorption / Moisture Content**

The samples casted are initially submerged in water at room temperature (25^{o}C to 30^{o}C) for 24 hours and weighed, then those wet samples were placed in an oven for 24 hours and weighed, keeping in view the guidelines of section 7 of ASTM C-67. Calculated as:

Absorption (%) = ($W_{saturated\ surface\ dry}$ – $W_{oven\ dried}$) x 100 / $W_{oven\ dried}$

h. **Combustion Performance**. the combustibility of the panel made out of selected mix proportion and formica laminate was done under the fire rating experiment.

i. **Fire Rating**. The fire rating of the panel was determined by exposing three samples at a temperature of 400^{o}C for a minimum duration of 4 hours. Based on visual inspection and weight loss the fire rating of the infill panel was judged.

j. **Anchorage Load**. The anchorage capacity of the panel has been checked using the pull-out testing approach and the hanging load method.

k. **Impact Strength**. This test (ASTM E-661) method covers procedures for determining the resistance to deflection and damage of floor and roof sheathing used in site-built construction subjected to concentrated static loads as well as impact loads from nonrigid blunt objects. It is applicable to wood and wood-based panels and boards, but is not intended to cover profiled metal decks, nor precast or cast-in-place slabs. Surface indentation is not evaluated separately from deflection.

l. **Acoustic Performance**. Actual procedure of carrying out this test was to construct a soundproof chamber with samples of infill panels followed by placing a mic inside the chamber and a transducer outside it so as to measure its acoustic performance. Due to paucity of resources this test was not carried out on ground, however literature can be referred to understand the results. Study done by Belmokaddem et al. (2020) in which they compared and evaluated the effect of substituting fine and coarse aggregate with three plastic wastes. The use of plastic waste in concrete formed a composite material having noteworthy acoustic insulation characteristics.

Chapter 4

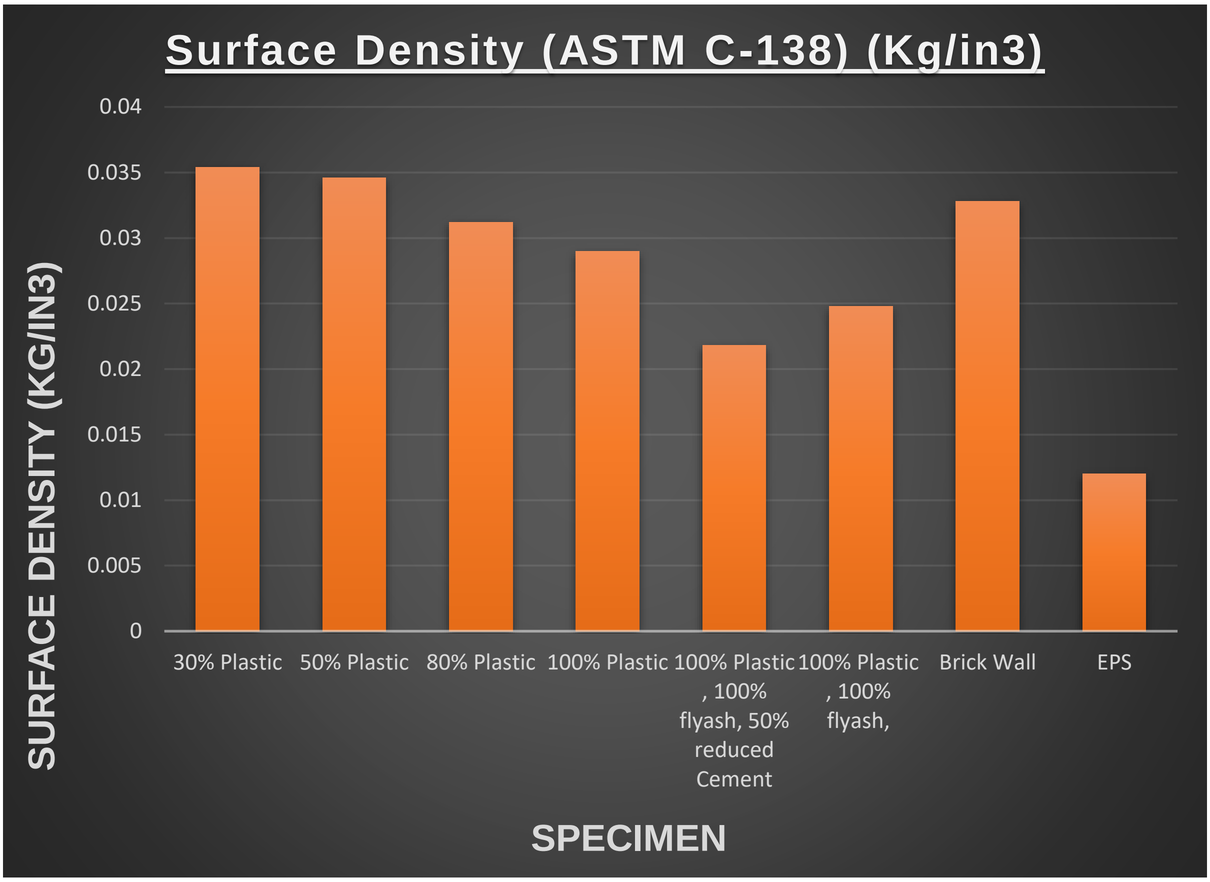
RESULTS AND DISCUSSION

This chapter deals with the study of some selected parameters of brick walls, EPS panels and recycled plastic waste + fly ash Infill Panel. Keeping in view the results of Compressive strength, surface density and other durability tests, a detailed comparative study between brick walls, EPS panels and recycled plastic waste + fly ash Infill Panel is made.

4.1 Surface Density (ASTM C-138).

All samples of different proportions (cubes 4" x 4") were cured for 28 days then their weight was taken and divided by its volume (64 in^3). Results are tabulated below:

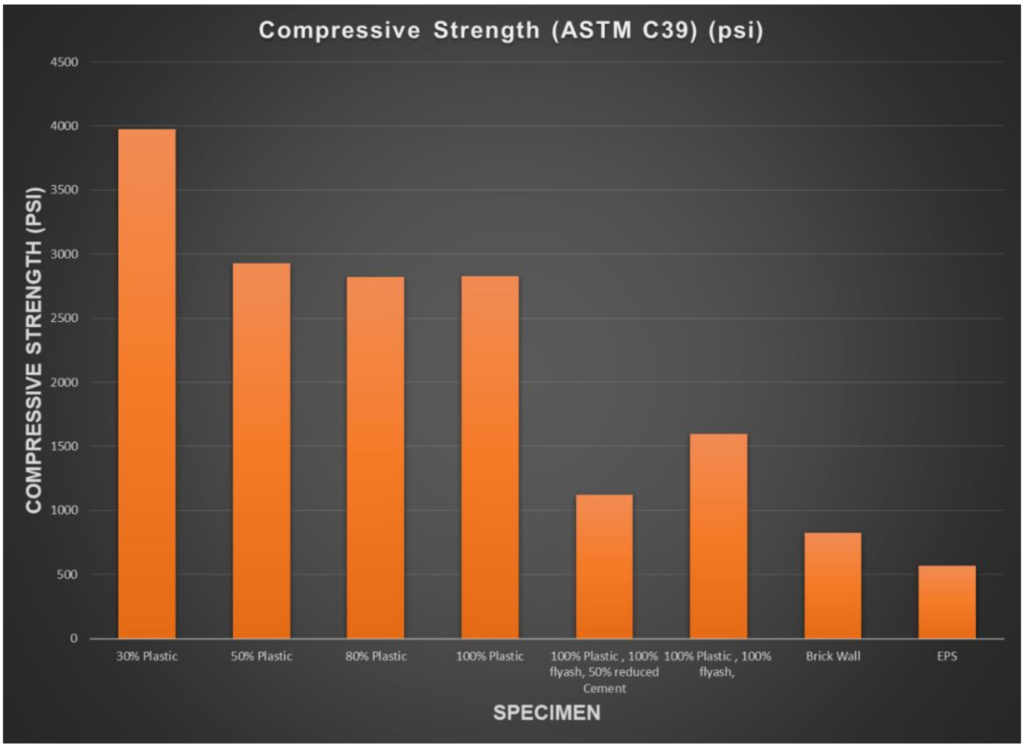
Surface Density (ASTM C-138) (Kg/in^3)	
Specimen	**Result**
30% Plastic	0.0354
50% Plastic	0.0346
80% Plastic	0.0312
100% Plastic	0.029
100% Plastic, 100% flyash, 50% reduced Cement	0.0218
100% Plastic , 100% flyash,	0.0248
Brick Wall	0.0328
EPS	0.012



4.2 Compressive Strength (ASTM C39).

Cylinders of 6" x 12" were casted for every sample and cured for 28 days then tested at the dynamics lab in the UTM under standard settings for compression strength as per ASTM C39. Test results are as tabulated below.

Compressive Strength (ASTM C39) (psi)	
Specimen	**Result**
30% Plastic	3972.39
50% Plastic	2928.88
80% Plastic	2819.53
100% Plastic	2825.33
100% Plastic , 100% flyash, 50% reduced Cement	1124.04
100% Plastic , 100% flyash,	1599.76
Brick Wall	826.71
EPS	566



4.3 <u>Water Absorption / Moisture Content.</u>

Cylinders of 3” x 6” were casted for every sample and cured for 28 days then weighed in three different ways:

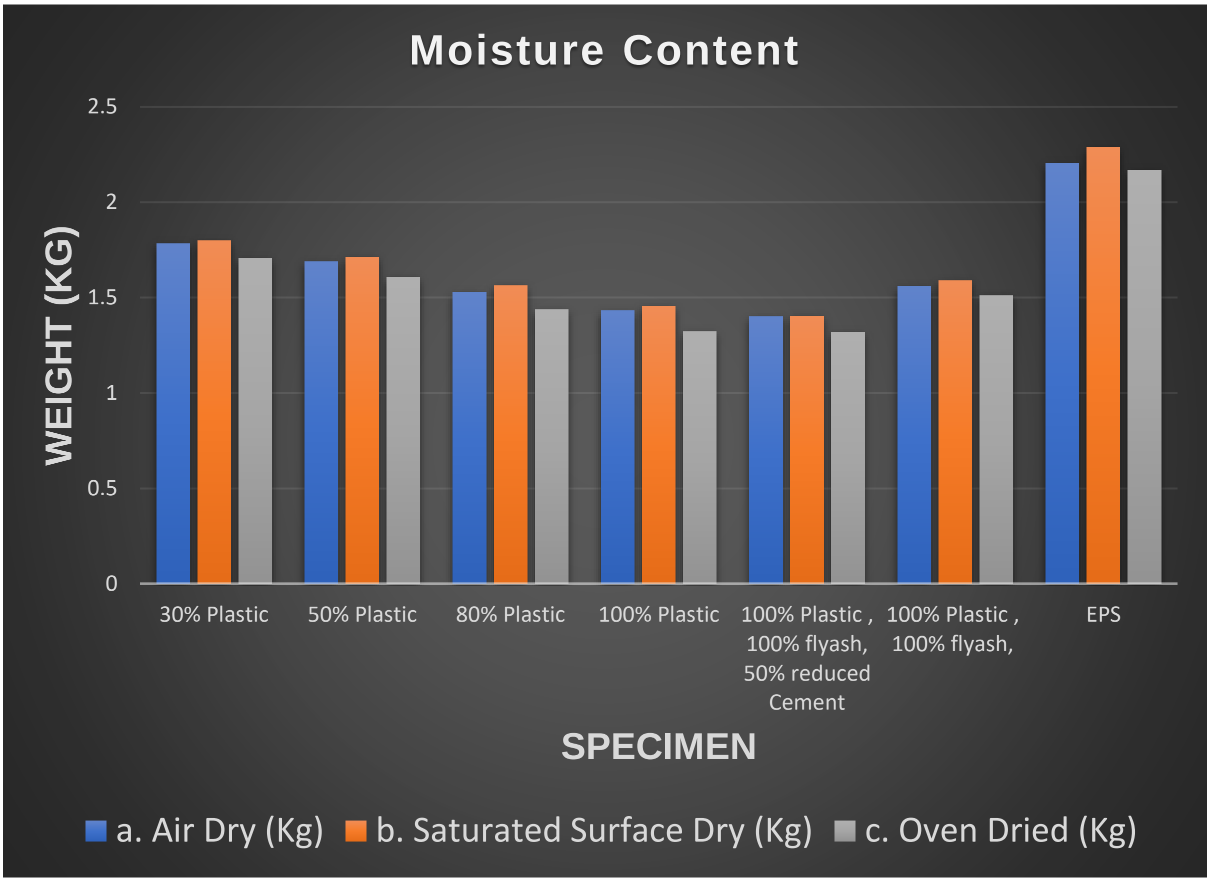
- **a.** Air dried (Kg)
- **b.** Saturated Surface Dried (Kg)
- **c.** Oven Dried (Kg)

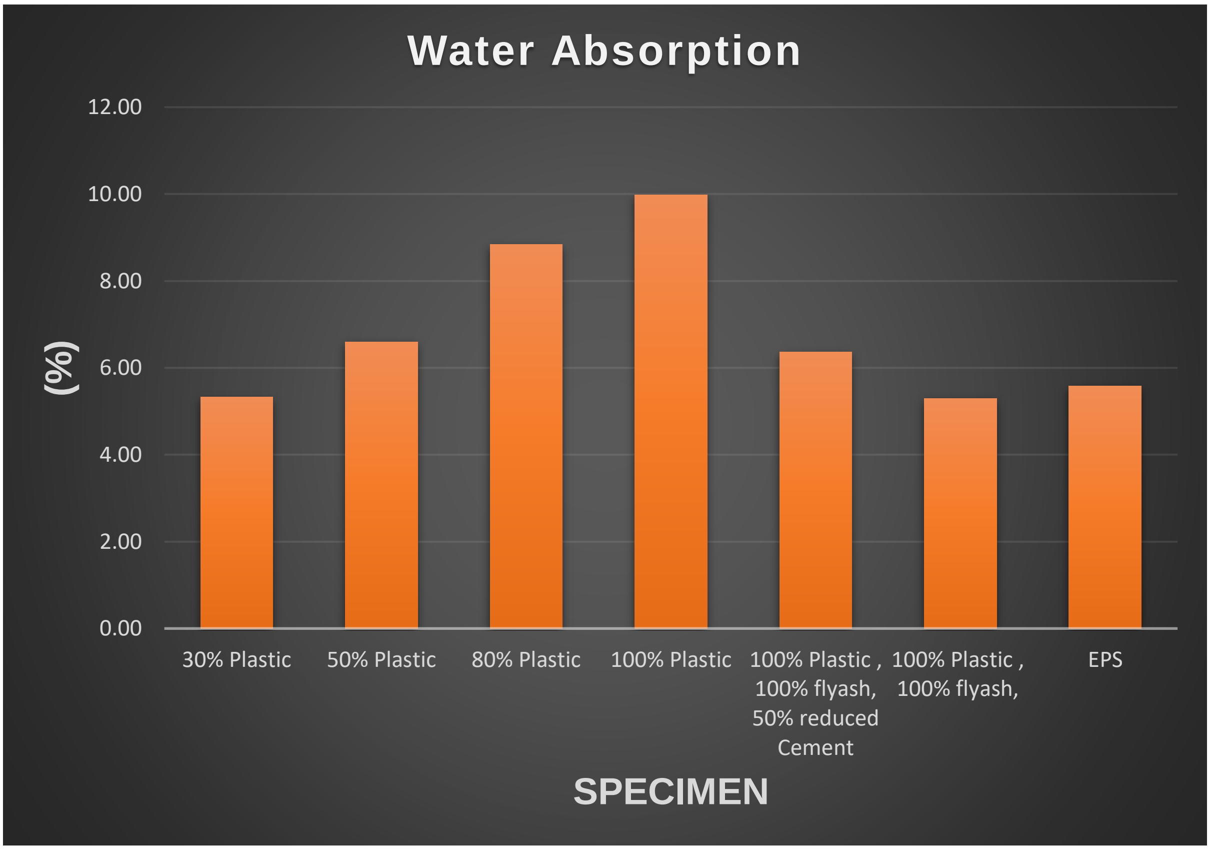
Keeping in view the guidelines of section 7 of ASTM C-67 absorption was calculated as:

Absorption (%) = $(W_{saturated\ surface\ dry} - W_{oven\ dried}) \times 100 / W_{oven\ dried}$

The results are tabulated below:

Specimen	Absorption/ Moisture content (%)	Air Dry (Kg)	Saturated Surface Dry (Kg)	Oven Dried (Kg)
30% Plastic	5.33	1.784	1.798	1.707
50% Plastic	6.60	1.689	1.713	1.607
80% Plastic	8.84	1.529	1.564	1.437
100% Plastic	9.98	1.431	1.455	1.323
100% Plastic , 100% flyash, 50% reduced Cement	6.36	1.4	1.404	1.32
100% Plastic , 100% flyash,	5.30	1.56	1.59	1.51
EPS	5.58	2.204	2.29	2.169


Moisture Content
WEIGHT (KG)
2.5
2
1.5
1
0.5
0
30% Plastic
50% Plastic
80% Plastic
100% Plastic
100% Plastic , 100% flyash, 50% reduced Cement
100% Plastic , 100% flyash,
EPS
SPECIMEN
a. Air Dry (Kg)
b. Saturated Surface Dry (Kg)
c. Oven Dried (Kg)


Water Absorption
(%)
12.00
10.00
8.00
6.00
4.00
2.00
0.00
30% Plastic
50% Plastic
80% Plastic
100% Plastic
100% Plastic , 100% flyash, 50% reduced Cement
100% Plastic , 100% flyash,
EPS
SPECIMEN

4.4 Combustion Performance.

The combustibility of the panel made out of selected mix proportion done under the fire rating experiment. The selected sample i.e. 100% plastic and 100% fly Ash replacing coarse and fine aggregate respectively with reduced cement content was placed in the furnace at Dynamics lab for 4 hours at a controlled temperature of 400 degree Celsius. It was observed that the sample disintegrated hence the sample cannot be classified as grade A noncombustible material.

4.5 Fire Rating.

The fire rating of the panel was determined by exposing the sample at a temperature of 400 C for a minimum duration of 4 hours. Based on visual inspection and weight loss the fire rating of the infill panel was judged. The experiment was to be conducted for three different increasing temperatures, however the sample disintegrated at 400 degree Celsius hence there was no need of conducting further experiments.

4.6 Anchorage Load.

The anchorage capacity of the panel has been checked using the pull-out testing approach and the hanging load method. It was observed that the pull out force required to pull a ½ " bolt from the panel was 4.2 KN. The hanging power of the panel was estimated by hanging a weight of 102 Kg from partition wall on site for a duration of 24 hours, as shown in the figure. After 24 hours, it was noticed that the panel partition wall supported the hanging force of 1000 KN without any cracks or fractures.

4.7 Impact Strength.

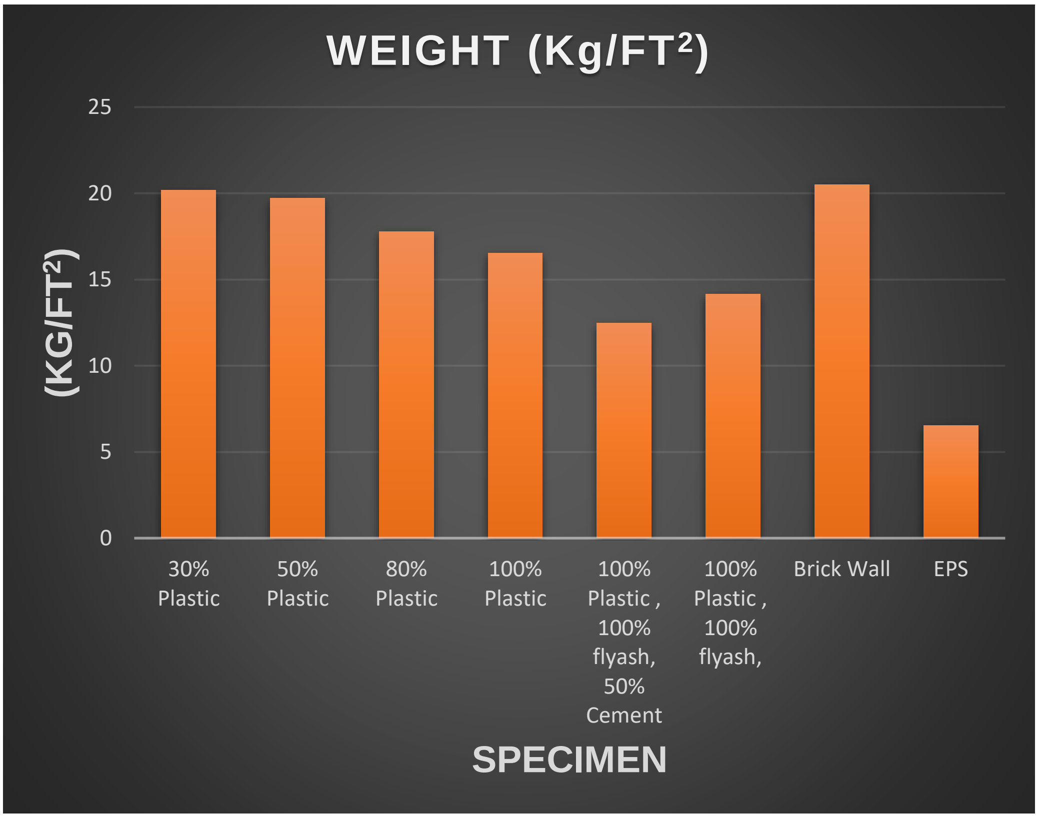
The Impact Strength of representative panel having dimensions of width 1' by 4' is tested as per ASTM E-661. The sample was placed on two roller supports, the impact load of 30 lbs was dropped on the surface of the panel, beginning with a drop height of 6 in. After passing each drop height, the impact height was increased at an increment of 6 in, measured from the bottom of the bag to the top surface of the panel. It was observed that the 50 mm thick panel sustained the impact load of 30 lbs at the height of 18 in without any visible damage.

Chapter 5

CONCLUSIONS

5.1 Unit weight of concrete

It was evident from the results that the Unit weight of concrete decreased as plastic aggregate and fly ash was added. The Unit weight of concrete decreased from 0.0383 Kg/in^3 to 0.0218 Kg/in^3 (56% reduction). The evident reduction in weight of concrete confirms the potential of plastic aggregate and fly ash for use in infill panels.



5.2 Compressive strength

It was evident from the results that the Compressive strength of concrete decreased with an increase of plastic aggregate and fly ash. 28 x days Compressive strength of concrete cylinders decreased from 4500 to 1124 Psi (28 % reduced), however the average strength of a brick wall is 826 psi and of EPS is 566 psi which means that the panel under consideration has greater strength than both.

5.3 Rate of absorption

Rate of absorption increased with an increase in the amount of plastic aggregate, however it decreased with addition of fly ash. It was observed after several measurements that the absorption of representative infill panel was 6.36%, whereas for an EPS panel it is 5.58 %.

5.4 Combustion Performance

Sample panel was exposed to elevated temperature of 400 degree Celsius and was observed that the material lost 20% weight in 4 hours. Hence in subsequent chapters the solution to this issue is recommended.

5.5 Anchorage loading

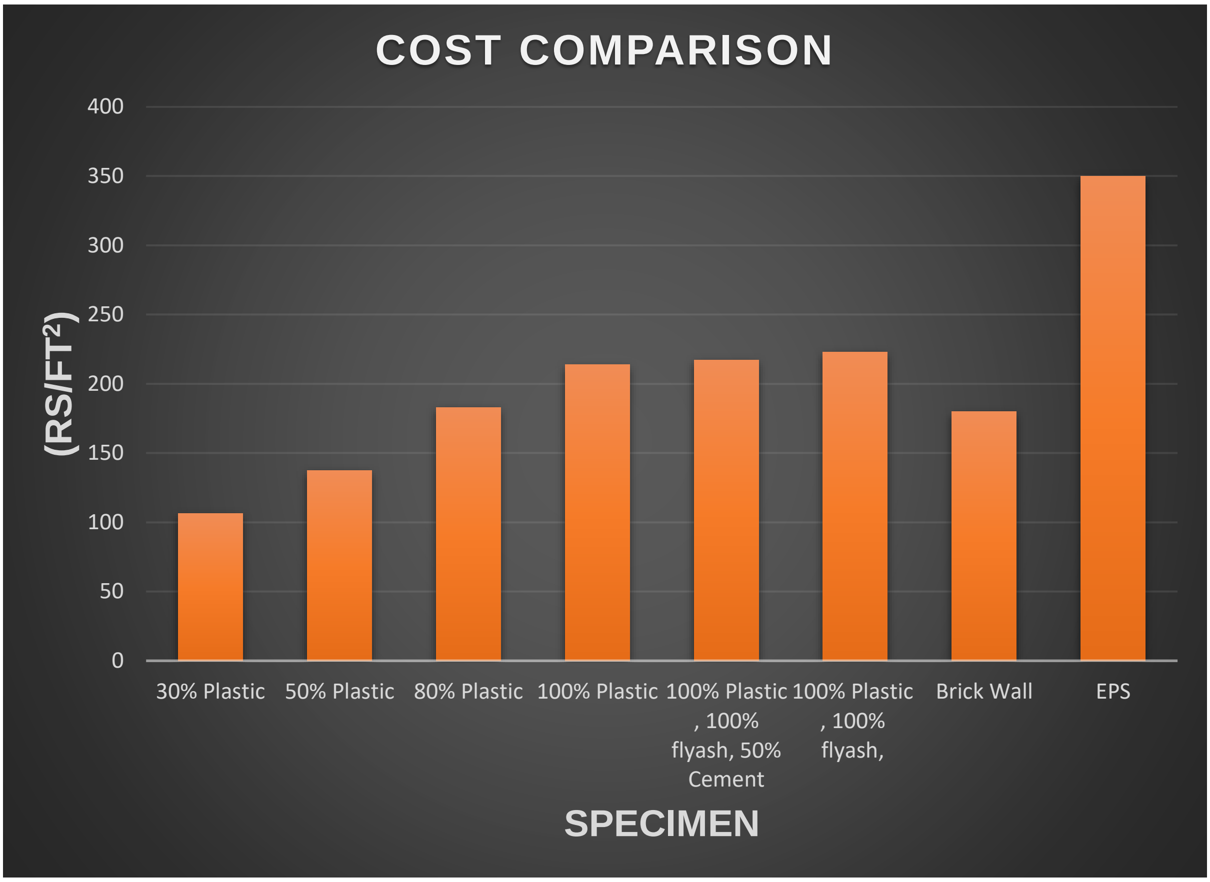
Anchorage loading was at par with EPS panels that are already in use in the market. A weight of 220 lbs can be hung from a 0.5 in bolt.

5.6 Impact strength

Impact strength was also at par with EPS panels. A panel of 1' by 4' with a thickness of 2 in can withstand an impact load 30 lbs from a height of 18 in.

5.7 Cost

The cost of the representative sample was found out to be less than the EPS panels currently used in the market whereas it was a little higher than the price of brick masonry. Overall, the proposed panel turned out to be most cost effective dur to its light weight and lower manufacturing cost. A cost comparison is as follows:


COST COMPARISON
(RS/FT2)
400
350
300
250
200
150
100
50
0
30% Plastic
50% Plastic
80% Plastic
100% Plastic
100% Plastic , 100% flyash, 50% Cement
100% Plastic , 100% flyash,
Brick Wall
EPS
SPECIMEN

Chapter 6

RECOMMENDATIONS

a. The designed panel is light weight and is recommended for high rise RCC frame structures to reduce the dead weight, which in turn would save the cost in terms of a lighter designed structure.

b. Fly ash used in the aggregate can be easily found as a waste product which is readily available and is cheap thus increasing the cost effectiveness and eco friendliness.

c. Use of recycled plastic waste will help in reducing plastic hazard, hence making the product environmentally friendly.

d. Formica sheet will be used as laminate to improve fire rating and combustion performance as it is a very good fire resistance property.

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