

USAGE OF EXPANDED POLYSTYRENE WASTE IN BUILDING CONSTRUCTION

Submitted in practical fulfillment of the requirements for the awards of
bachelor of engineering degree in civil engineering

By

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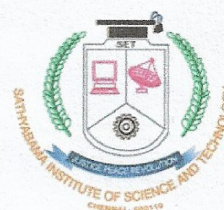
**DEPARTMENT OF CIVIL ENGINEERING
SCHOOL OF BUILDING AND ENVIRONMENT
SATHYABAMA
INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade "A" by NAAC
JEPPIAAR NAGAR, RAJIVGANDHI SALAI,
CHENNAI-600119**

APRIL 2022



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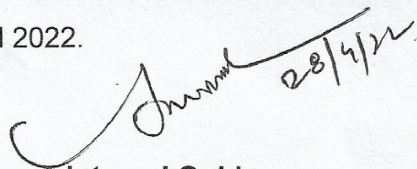
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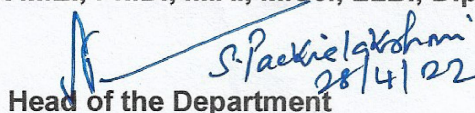
BONAFIDE CERTIFICATE

This is to certify that this project report is the bonafide work of **S.BALA MURUGAN** (Reg.no.38200041) and **S.ALBERT JAMES PELIES** (Reg.no.38200701) who carried out the project entitled "**USAGE OF EXPANDED POLYSTRENE WASTE IN BUILDING CONSTRUCTION**" under our supervision from November 2021 to April 2022.

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DECLARATION

We **S.BALAMURUGAN (Reg.no.38200041)** and **S.ALBERT JAMES PELIES (Reg.no.38200701)** hereby declare that the project report entitled "**USAGE OF EXPANDED POLYSTRENE WASTE IN BUILDING CONSTRUCTION**" Done by us under the guidance of **Dr.V.SAMPATHKUMAR M.E., Ph.D., M.A., M.Sc., LLB., Dip in IRT Delhi** is submitted in practical fulfillment of the requirements for the award of Bachelor of Engineering degree in Civil engineering

DATE:

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ACKNOWLEDEMENT

We are pleased to acknowledge our sincere thanks to the board of management of SATHYABAMA for their kind encouragement in doing this project and for completing it successfully. We are grateful to them.

We convey our thanks to **Dr.Devyani Gangopadhyay, B.Arch.,M.T.P.,Ph.D.**, dean school of building and Environment and **Dr.S.Packialakshmi, M.E, Ph.D.**, and **Dr.R.Padmapriya, M.E.,Ph.D.**, head of the department, dept of civil engineering for providing necessary support and detail at the right time during the progressive reviews.

We would like to express our sincere and deep sense of gratitude to our project guide **Dr.V.SAMPATH KUMAR M.E., Ph.D., M.A., M.Sc., LLB., Dip in IRT Delhi** for his valuable guidance, suggestions, and constant encouragement that paved way for the successful completion of my project work.

We wish to express our thanks to all teaching and non-teaching staff members of the department of Civil Engineering who were helpful in many ways for the completion of the project.

ABSTRACT

To avoid polluting gas emissions, cement with a large carbon footprint is being replaced. Expanded polystyrene is being investigated as a possible replacement for cement mortar in light brickwork construction. Expanded polystyrene mortar mixtures were generated by melting expanded polystyrene beads in acetone and determining the full mix. After that, it was compared to regular Portland cement mortar. Expanded polystyrene mortar has a lower binding strength than cement mortar, according to the findings. Although expanded polystyrene mortar has a higher compressive strength than cement mortar, it absorbs less water. It can be used for solid filling of non-load-bearing applications with limited outside use, as well as for recycling non-perishable EPS waste. The disposal of expanded polystyrene goods is a global environmental issue, and the construction industry deserves a lot of credit for using expanded polystyrene mortar. This study not only demonstrates that an environmentally friendly, energy-efficient, and long-lasting alternative to cement-based building may be achieved, but also that it can be done

Keywords: Thermocol, Acetone, Partial replacement

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LIST OF SYMBOLS & ABBREVIATIONS

Acronyms	Expansions
%	Percentage
Kg	Kilogram
Cm	Centimeter square
Mm	Millimeter
EPS	Expanded Polystyrene

CHAPTER – 1

INTRODUCTION

1.1 THERMOCOL

1.1.1 Amount of thermocol waste produced in India

While some EPS gets recycled, the most of it ends up in a landfill, where one of the largest issues is its size.

Although EPS only takes 1% of the weight in the dump, the rate of dumping is substantially higher.

There is also evidence that one of the components of EPS, styrene, is a human carcinogen; it is critical that the EPS be recycled or that the landfill be confined and not allowed to reach streams and rivers

1.1.2 What is Thermocol beads?

The monomer styrene is used to create a synthetic aromatic hydrocarbon polymer. Polystyrene comes in two forms: solid and foamed. Polystyrene is a translucent, brittle, and rigid substance. In terms of unit weight, it is a low-cost resin. It has a low melting point and performs poorly as an oxygen and water vapor barrier. With yearly production rates in the millions of tons, polystyrene is one of the most widely used polymers. Polystyrene, which is naturally translucent, can be colored with colorants. Containers, lids, bottles, trays, tumblers, throwaway cutlery, model fabrication, and as a replacement material for phonographs are just a few of the uses for this material.

Polystyrene is a thermoplastic polymer that is solid (glassy) at room temperature but flows when heated over the glass transition temperature of about 100 degrees Celsius. It recovers to its original rigid state when it cools. Its temperature behavior is employed for extrusion (as in Styrofoam), moulding, and vacuum shaping because it can be cast into moulds with precise precision.

According to ASTM regulations, polystyrene is not biodegradable. It is accumulating as litter in the environment, particularly along coasts and waterways, as well as in the Pacific Ocean in its foam form.

1.1.3 Recycling of plastic waste

An unwanted or undesired materials or substance is considered as the Waste or trash, junk, garbage, depending on the type of materials or the local terminology. It may consist of manufacturing leftovers (industrials and commercial) or from community of people and their household activities. Before recycling these materials are dismantled and then collected, stored later treated (physically, chemically, or biologically), before being recycling. They are wastes which used inappropriately. Plastic is a synthetic material which is made up of polymerizing molecular of monomer, materials which are derived from coal, petroleum or natural gas. Proper way of handling plastic waste is to recycle them which is more desirable because it would avoid their accumulation in landfills.



Fig:1.1: Thermocol beads

1.1.4 Waste Thermocol and Its Management

- Benefit of use of Thermocol waste in bitumen has been found both eco-friendly and economical.
- Thermocol waste material may replace the costly imported additives like SBS and EVA and also reduce the amount of bitumen used in making construction of bituminous layers more economical.
- Disposal of Thermocol waste will be reduced in future since it can be used in hot bituminous mixes. This directly relates to environment

friendly by disposing waste material judiciously and reducing the concept of importing materials at higher cost. This benefits in the saving of public money. The benefit accrued by adding Thermocol waste is to enhance the quality of such mixes in the performance and design life of asphaltic roads. Also, it will be contributing to a cleaner and greener environment by using of plastic wastes in the road construction.

18.6 Acetone

Acetone, also known as propanone or dimethyl ketone, is a ketone with the formula $(CH_3)_2CO$. It is the simplest and tiniest of the ketone family. It's a colorless, highly combustible liquid with an unpleasant odor.

Acetone is a miscible organic solvent that is utilized in industry, at home, and in research labs. Bisphenol was manufactured in 6.7 million tons worldwide in 2010, mostly as a solvent and in the production of methyl methacrylate (and hence PMMA) and bisphenol. It is a common building block in organic chemistry. Acetone can be found in a wide range of household items, including nail polish remover and paint thinner. It is not subject to volatile organic compound (VOC) laws in the United States.

Acetone is produced and removed by the human body's normal metabolic processes. It's most commonly detected in the blood and urine. In diabetic ketoacidosis patients, it is produced in larger levels. According to reproductive toxicity testing, it has a small chance of creating problems with reproduction.

Ketogenic diets, which raise blood levels of ketone bodies (acetone, -hydroxybutyric acid, and acetoacetic acid), are used to prevent epileptic seizures in infants and children with refractory epilepsy.



Fig:1.2: Acetone

CHAPTER – 2

LITERATURE STUDY & METHODOLOGY

2.1 REVIEW OF LITERATURE

First of all, various books and journals were collected for reference and were studied before starting the project work for having an idea about how the project should be. In this project n Thermocol waste and plastic waste in road are introduced.

Journal name: Cement and Concrete Research 37 (2007) 1666–1673

Author name: D. Bouvard, J.M. Chaix, R. Dendievel, A. Fazekas, J.M. Létang, G. Peix, D. Quenard

Summary: Compared to thermal conductivity data the stiffness and the strength of the expanded polystyrene is insignificant. The expanded polystyrene good at allowing air members and workable, which makes the light weight and workable. The compression test on expanded polystyrene in light weight concrete is at minimal range. Under microscope it seen that it is has high density in the concrete. The bond strength is increased at the low content of expanded polystyrene is added in concrete.

Journal name: Cement and Concrete Research 33 (2003) 755 – 762

Author name: K. Ganesh Babu, D. Saradhi Babu

Summary: silica fume and expanded polystyrene in cement concrete increase the strength and bulk density. The compressive strength and the tensile strength are comparatively even to the strength of cement mortar. The low proportion of expanded polystyrene produced good bond strength

Journal name: Construction and Building Materials 253(2020)119158

Author name: Amrita Milling, Abrahams Mwasha, Hector Martin

Summary: The strength of expanded polystyrene with sharp sand mortar is twice greater than the cement mortar. In water absorption test they have given the results in same. At water permeability test the results were even. At the tensile, compression and flexural test the cement mortar results were greater than expanded polystyrene sharp sand mortar. At bonding test the ratio mix of sample shows that when the mix of expanded polystyrene content is heavy in sharp sand mortar, the bonding strength is decreased. When the mix of expanded polystyrene content is low in the sharp sand mortar, the bonding strength is increased. The proportions of low expanded polystyrene in sharp sand mortar dries faster than the high expanded polystyrene content in sharp sand mortar.

**Journal name: Use of Recycled Plastics in Eco-efficient Concrete (2019)
p.137-165**

Author name: J.M. Khatib, B.A. Herki, A. Elkordi

Summary: The expanded polystyrene is added in cement mortar as replacement of aggregates fails to match the normal cement mortar aggregates. The more content of expanded polystyrene leads to elasticity fail, where in compression test also it fails. Its more like work as air void where the mechanical failures happened. The split tensile strength also low compared to normal mortar. When the proportion of expanded polystyrene is low in the mortar, the strength is increased.

Journal name: Construction and Building Materials 49(2013)315-327

Author name: Ana Brás a, Márcio Leal a, Paulina Faria

Summary: The thermal behavior of the expanded polystyrene is analyzed under microscopic condition under all entry level test. Shows that the expanded polystyrene cement mortar fails when compared to cork cement mortar even though low consistency is maintained. At water absorption test the expanded

polystyrene mortar absorbed less water comparing to the cork mortar, The expanded polystyrene mortar failures in tension test and compression test.

Journal name: Journal of Urban and Environmental Engineering, v.11, n.2, p.219-225

Author name: Adriane Pczieczek, Adilson Schackow, Carmeane Effting, Talita Flores Dias and Itamar Ribeiro Gomes

Summary: The mortar with rubber powder and low content of expanded polystyrene has increased the air content in the mortar. It reduced the specific gravity. The expanded polystyrene has contributed a increase in workability. The expanded polystyrene has increased in water absorption and voids ratio. The expanded polystyrene and made the mortar workable and light weight.

Journal name: Applied polymer science (2019)47529

Author name: Nor Hafizah Ramli Sulong, Siti Aisyah Syaerah Mustapa, Muhammad Khairi Abdul Rashid

Summary: The expanded polystyrene is delicate towards the solvent assail. The expanded polystyrene has no issues with salt or water. When the expanded polystyrene reacts with the solvent it dissolves and becomes yellowish liquid state. It works as a air entering factor in mortar which increase the workability. The expanded polystyrene has also worked as an good insulator factor for the mortar.

Journal name: The Mining-Geology-Petroleum Engineering Bulletin Vol.34 no.3(2019)284-288

Author name: Gordan Bedeković, Ivana Grčić², Aleksandra Anić Vučinić², Vitomir Premur²

Summary: when we add high content of cement and sand in expanded polystyrene concrete, the bulk density and the strength of concrete is increased. Using the correct proportion of expanded polystyrene in concrete increase the bonding strength. It increases the workability of the expanded polystyrene in concrete.

Proves that the addition of plastic in the innovative technology which is strong then the road construction

Journal name: International Research Journal of Engineering and Technology Vol.6 June 2019

Author name: Hitesh Patidar¹, Mayur Singi², Abhijeet Bhawsar

Summary: The workability of the expanded polystyrene is increased in low water cement ratio and in low proportions the strength is increased.

Journal name: Construction and Building Materials 236 (2020) 117789

Author name: Fuat Koksall a, Emrah Mutluay b, Osman Gencel

Summary: expanded polystyrene and vermiculate are added in mortar. The expanded polystyrene and vermiculate doesn't provide good bond strength, thermal and failure in mechanical properties

Journal name: J Therm Anal Calorim 126,1123-1132 (2016)

Author name: Mingxu Chen, Shoude Wang, Lingchao Lu, Piqu Zhao¹, Chenchen Gong¹

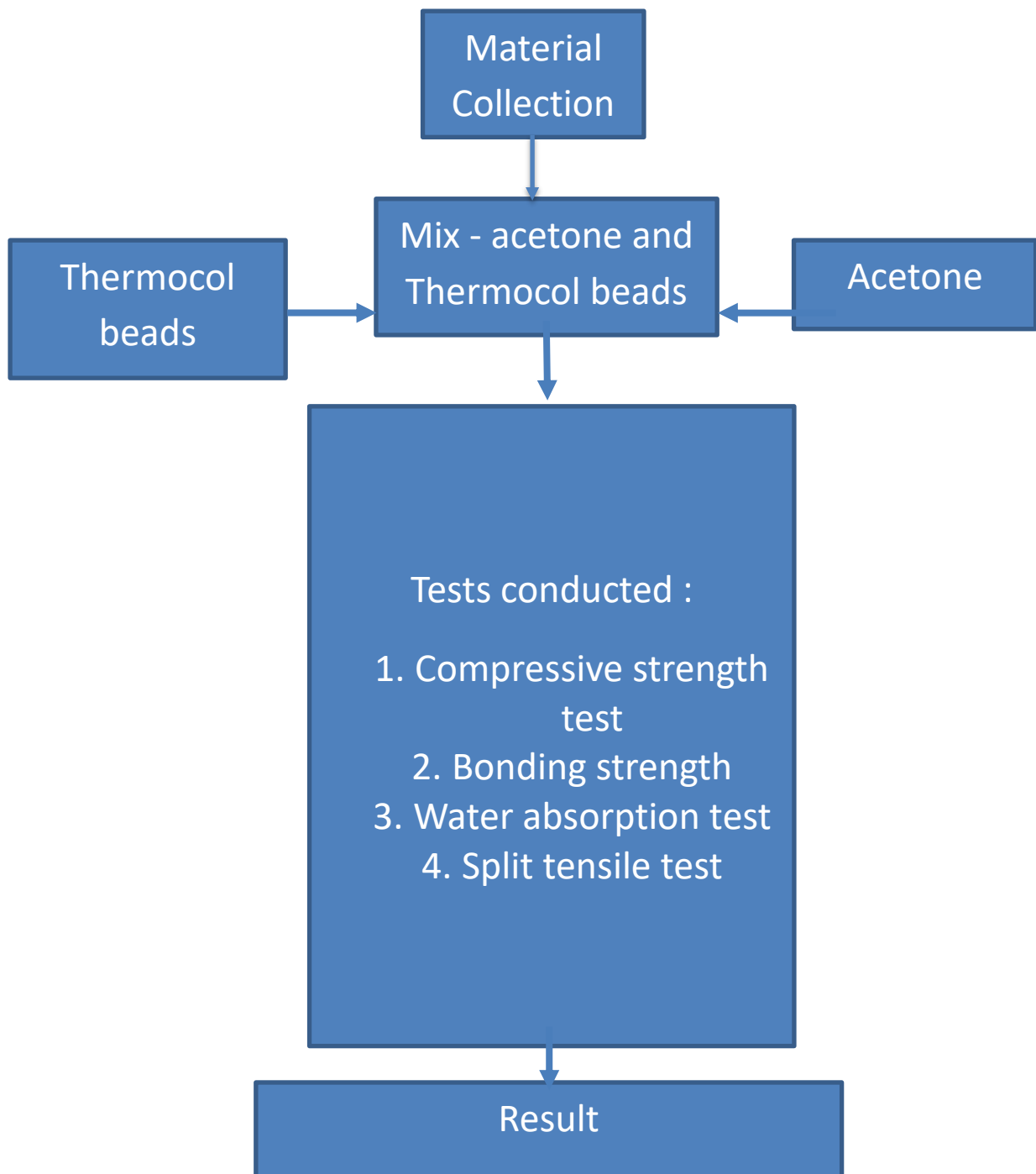
Summary: cement expanded polystyrene and vitrified microsphere mortar is made and compared the thermal insulation of expanded polystyrene is comparatively low.

Journal name: Environmental Science and Pollution Research 28,50028-50051(2021)

Author name: Nahla Hilal, Nadhim Hamah Sor, Rabar H. Faraj.

Summary: when the volume of the expanded polystyrene is increased the durability and performance is high. Mixture of expanded polystyrene is low to produce high strength mortar.

2.2 METHODOLOGY



CHAPTER 3

OBJECTIVES

3.1 OBJECTIVE

- To find the bonding strength of expanded polystyrene mortar comparing to cement mortar.
- To check the compressive strength & tensile strength of the expanded polystyrene mortar.
- To check the water absorption of expanded polystyrene mortar.
- To check the solubility of expanded polystyrene using organic solvent.
- To check that no harmful gas is released at the time of dissolving the expanded polystyrene in organic solvent

CHAPTER 4

MATERIALS USED

4.1 THERMOCOL BEADS

- Thermocol beads, foam material then made of expandable polystyrene beads.
- It will available in all shops
- Polystyrene known as non-corrosive, voluminous and extremely hazardous to the environment
- It is not a sustainable practice to dump EPS in landfills as it takes a large volume that is no
- t necessary for a small weight
- Because of these negative effects, many countries are preventing imports of EPS products.



Fig:4.1 : THERMOCOL BEADS

4.2 Acetone

Acetone is a miscible organic solvent that can be utilized in the workplace, at home, or in the lab. In 2010, around 6.7 million tons were produced globally, primarily as a solvent and in the manufacturing of methyl methacrylate (and hence PMMA) and bisphenol. In organic chemistry, it is a common building block. Acetone can be found in a variety of products around the house, such as nail polish remover and paint thinner. In the United States, it is not subject to volatile organic compound (VOC) laws.

Acetone is produced and removed by the human body's normal metabolic processes. It's most commonly found in the blood and urine.



Fig: 4.2: Acetone

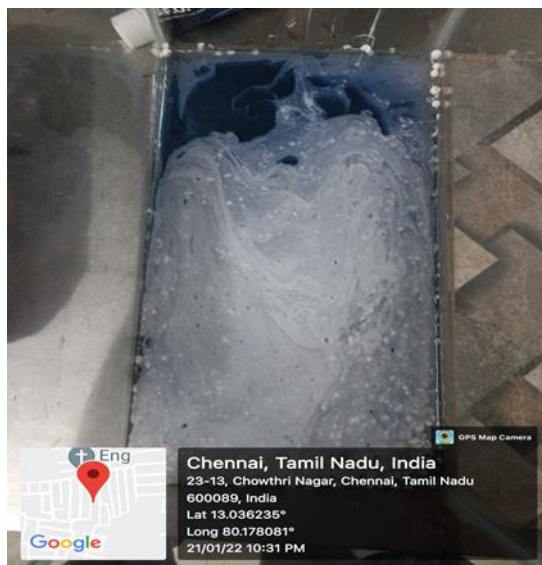


Fig: 4.2.1: Thermocol beads mixed with Acetone

18.6 COMPARISON WITH CEMENT MORTAR

Cement mortar composites are used extensively in masonry work, plastering, restoring damaged concrete, patching or filling, rendering, floor levelling, and the production of precast products.



4.3 cement mortar

4.4 ADHESIVE

- the expanded polystyrene beads are partially dissolving in the acetone (within a second).
- the expanded polystyrene beads are fully dissolving in the acetone (within 5min).
- the expanded polystyrene adhesive is applied on brickwork.



18.6 EPS adhesive

CHAPTER 5

TEST ON EPS ADHESIVE MORTOR AND CEMENT MORTOR

5.1 COMPRESSIVE TEST

Test Method – IS: 3495

The test is done on both specimens, no entry test is done.

The compressive strength of each specimen values are observed and noted

They were tested at the period range of 7,14,28 days healed.

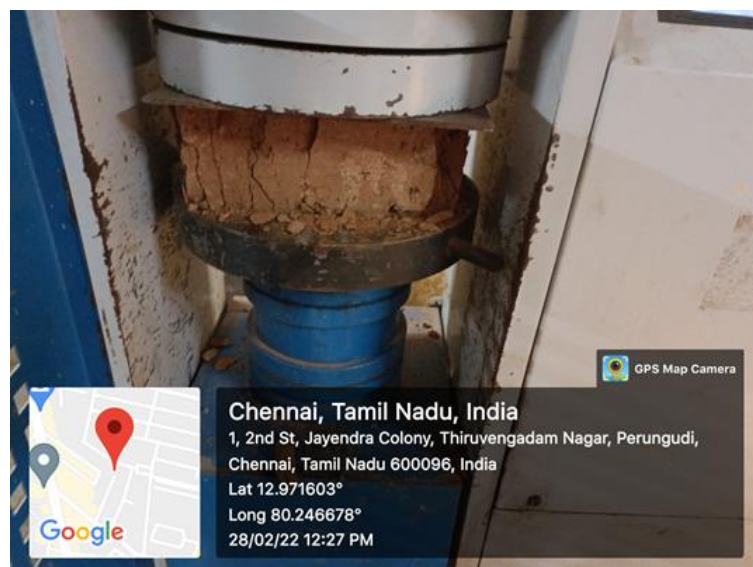


Fig:5.1: COMPRESSIVE STRENGTH TESTING MACHINE

DAYS	COMPRESSIVE STRENGTH OF CEMENT MORTOR	COMPRESSIVE STRENGTH OF EPS ADHESIVE
7	267.75 kN/mm ²	154.17 kN/mm ²
14	263.61 kN/mm ²	204.96 kN/mm ²
28	338.84 kN/mm ²	227.81 kN/mm ²
Average compressive strength	290.06 kN/mm ²	195.64 kN/mm ²

Table 5.1 compressive strength results

5.2 BONDING STRENGTH TEST

Test Method – IS: 3495

The test is done on both specimen cement mortar and expanded polystyrene mortar masonry specimen.

The test was done without any entry test and periodically tested for about 7,14,28 days healed specimen. And the values are observed and noted

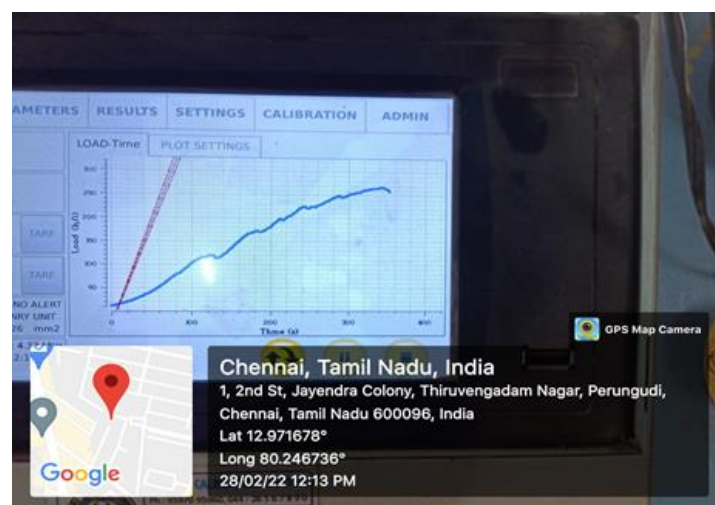


Fig: 5.2: Bonding Test Machine

Table 5.2: bonding test results

DAYS	BONDING STRENGTH –CEMENT	BONDING STRENGTH- EPS ADHESIVE
7	6.4	6
14	4.2	4.2
28	3.0	3.0
Average bonding strength	7.0 min	4.3 min

5.3 SPLIT TENSILE TEST

Test Method – IS: 3495

Split Tensile Strength Test

The specimens were made in cube of 150mm*300mm

The test is done on both specimen cement mortar and expanded polystyrene mortar without any entry test

The tensile strength of each specimen tested at a period of,7,14,28 and the values are observed and noted

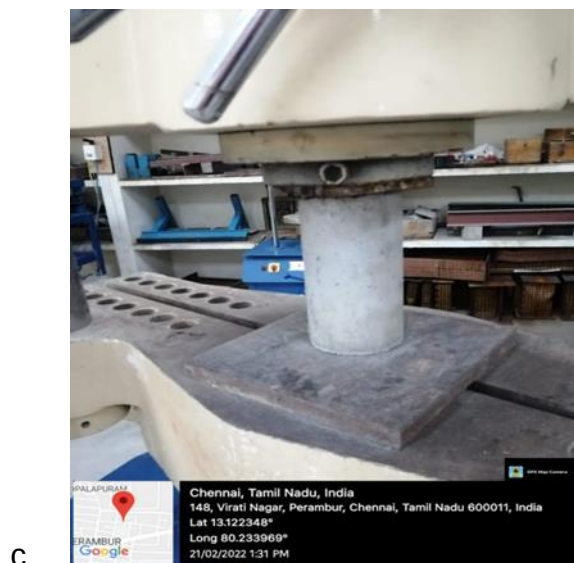


Fig: 5.3: Split tensile test Apparatus

Table 5.3: split tensile test results

DAYS	COMPRESSION ON CEMENT CUBE	COMPRESSION ON EPS ADHESIVE CUBE
7	122 kN/mm ²	12 kN/mm ²
14	193 kN/mm ²	17 kN/mm ²
28	206 kN/mm ²	27 kN/mm ²
AVERAGE	173.67 kN/mm ²	18.6 kN/mm ²

5.4 WATER ABSORPTION TEST

Test Method – IS: 3495

The expanded polystyrene mortar cube was made and it was weighted it was been soaked for about 24hrs in water.

The next day after 24hrs the specimen is weighted and values are noted.

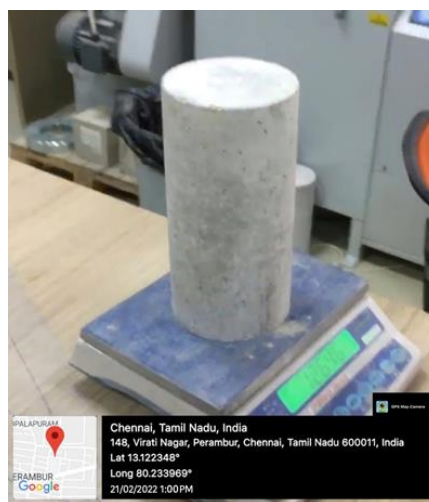


Fig: 5.4: Water absorption test

Table5.4: Water absorption test results

S.NO	DETERMINATION NO	SAMPLE 1 (kg)	SAMPLE 2 (kg)
1	Weight of saturated surface sample	12331	12342
2	Water absorption	12355	12376
3	Water absorption	0.4%	0.27%

CHAPTER- 6

CONCLUSION

- Due to shortage of cement raw materials, we are partially replacing with expanded polystyrene waste.
- Using the expanded polystyrene waste reduces the environmental pollution and eco-friendly to nature.
- The expanded polystyrene beads which dissolved on acetone to make the mortar and applied on brick masonry.
- At the time of dissolving the expanded polystyrene on organic solvent- acetone there is no harmful gas is released.
- The expanded polystyrene beads got fully dissolved in the organic solvent acetone.
- The expanded polystyrene mortar is compared with the cement mortar
- Comparing the cement mortar and the expanded polystyrene mortar the results gained was not equal.
- The expanded polystyrene mortar external layer only healed but the outer layer is not healed this reduces the bond strength compressive strength and tensile strength comparatively low to cement.
- At the water absorption test the expanded polystyrene does not absorb and water is only entered to pores. This shows that the expanded polystyrene is water resistant.
- Even though the results of the expanded polystyrene mortar was not equal to the cement mortar results, we can use it in non-load bearing structures and hollow fillings.
- In future we are planning to use sand in the expanded polystyrene mortar and compare it with cement mortar



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