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# Usage of Expanded Polystyrene Waste in Building Construction

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**Abstract**- ***To avoid polluting gas emissions, cement with a large carbon footprint is being replaced. Extended polystyrene is being investigated as a possible replacement forcement mortar in light brickwork construction. Expanded polystyrene mortar mixtures were generated by melting expanded polystyrene beads in acetone and determining the full mix and it was compared to ordinary Portland cement mortar. According to the findings the expanded polystyrene mortar has a lower binding strength than cement mortar. Expanded polystyrene mortar has a higher compressive strength than cement mortar and it absorbs lesser 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.***

**Keywords**: Thermocol, Acetone, expanded polystyrene mortar, comparing, cement mortar

## 1. Introduction

While some Expanded Polystyrene (EPS) gets recycled, the most of it ends up in a landfill, where one of thelargest 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 andnot allowed to reach streams and rivers. The monomer styrene is used to create a synthetic aromatic hydrocarbon polymer. Polystyrene comes in two forms such as solid and foamed. Polystyrene is a translucent, brittle and rigid substance. It is a low-cost resin. It has lowmelting point and performs as an oxygen and water vapor barrier. With yearlyproduction rate in the millions of tons, polystyrene is one of the most 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 at $100^0$C. It recovers to its original rigid state when it cools. Its temperature behavior is employed for extrusion (as in Styrofoam), molding and vacuum shaping because it can be cast into moulds with precise precision. Thermocol beads are shown in Figure 1. 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.

## 2. 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 materialsare dismantled and collected, stored later treated (physically, chemically, or biologically), before being recycling. They are wastes which are 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 are more desirable because it would avoid their accumulation in landfills.

Usage of Thermocol waste in bitumen has been found eco-friendly and economical. It may replace the costly imported additives like styrene–butadiene–styrene (SBS) and ethylene vinyl acetate (EVA) and reduce the quantity of bitumen used in bituminous layers. Disposal of Thermocol waste will be reduced if it is used in hot bituminous mixes. This helps in environment friendly by disposing waste material judiciously and reducing the concept of importing materials at higher cost. This will benefit the savings 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 bitumen roads. It will contributing to a cleaner and greener environment by using of plastic wastes in road construction.

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

**Figure 1:** Thermocol beads

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 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. 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.

## 3. Review of Literature

Various journals were studied before starting this work. In this project Thermocol waste and plastic waste in road are introduced. Ganesh Babu K, D Saradhi Babu (2003) said that silica fume and expanded polystyrene in cement concrete increased the strength and bulk density. The compressive strength and the tensile strength were comparatively even to the strength of cement mortar. The low proportion of expanded polystyrene produced good bond strength in concrete [1]. Bouvard D et al (2007) said that compared to thermal conductivity data the stiffness and the strength of the expanded polystyrene were insignificant. The expanded polystyrene was good at allowing air members and workable, which makes the light weight and workable. The compression test on expanded polystyrene in light weight concrete was at minimal range. The bond strength was increased at the low content of expanded polystyrene added in concrete [2].

AnaBrás et al (2013) said that the thermal behavior of the expanded polystyrene was analyzed under microscopic condition under all entry level tests. It showed that the expanded polystyrene cement mortar fails when compared to cork cement mortar even though low consistency was maintained. At water absorption test the expanded polystyrene mortar absorbed less water comparing to the cork mortar, The expanded polystyrene mortar failed in tension test and compression test [3]. Chen Mingxu et al (2016) said that the cement expanded polystyrene and vitrified microsphere mortar was made and compared the thermal insulation of expanded polystyrene was comparatively low [4]. Adriane Pczieczek et al (2017) said that the mortar with rubber powder and low content of expanded polystyrene had increased the air content in the mortar. It reduced the specific gravity. The expanded polystyrene had contributed an increase in workability. The expanded polystyrene had increased in water absorption and void ratio. The expanded polystyrene made the mortar workable and light in weight [5].

Khatib JM et al (2018) said that the expanded polystyrene was added in cement mortar as replacement of aggregates fails to match the normal cement mortar aggregates. The more content of expanded polystyrene lead to elasticity fail, where in compression test also it fails. It worked as air void where the mechanical failures happened. The split tensile strength also low compared to normal mortar. When the proportion of expanded polystyrene was low in the mortar, the strength was increased [6]. Gordan Bedeković (2019) said that when high content of cement and sand added in expanded polystyrene concrete, the bulk density and the strength of concrete was increased. Using the correct proportion of expanded polystyrene in concrete increased the bonding strength. It increased the workability of the expanded polystyrene in concrete proved that the addition of plastic as the innovative technology which would strong in the road construction [7]. Hitesh Patidar et al (2019) said that the workability of the expanded polystyrene was increased in low water cement ratio and in low proportions the strength was increased [8].

Nor Hafizah Ramli Sulong et al (2019) said that the expanded polystyrene was delicate towards the solvent assail. The expanded polystyrene had no issues with salt or water. When the expanded polystyrene reacted with the solvent it dissolves and become yellowish liquid. It worked as an air entering factor in mortar which increases the workability. The expanded polystyrene had also worked as a good insulator factor for the mortar [9]. Amrita Milling et al (2020) said that the strength of expanded polystyrene with sharp sand mortar was twice greater than the cement mortar. In water absorption test they had 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 showed that when the mix of expanded polystyrene content was heavy in sharp sand mortar, the bonding strength was decreased. When the mix of expanded polystyrene content was low in the sharp sand mortar, the bonding strength was increased. The proportion of low expanded polystyrene in sharp sand mortar dried faster than the high expanded polystyrene content in sharp sand mortar [10].

Fuat Köksal (2020) said that expanded polystyrene and vermiculate were added in mortar. The expanded polystyrene and vermiculate did not provide good bond strength, thermal and failure in mechanical properties [11]. Nahla Hilal et al (2021) said that when the volume of the expanded polystyrene was increased the durability and performance was high. Mixture of expanded polystyrene was low to produce high strength mortar. By disposing waste material

judiciously and reducing the concept of importing materials at higher cost. These benefits will save huge 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 road construction [12]. The objective of this study is to check the expanded polystyrene mortar's solubility in organic solvent, to check the release of harmful gas and to find the bonding strength, compressive strength, tensile strength and water absorption level and the obtained values to be compared with general cement mortar.

## 4. Materials Used

Thermocol Beads and Acetone are used out of which Thermocol beads a foam material is made up of EPS beads. It is easily available in local shops. Polystyrene is a non-corrosive, voluminous and extremely hazardous to the environment. It is not good to dump EPS in landfills as it takes a large space. Because of its negative effect many countries are preventing import of EPS products. Acetone is a miscible organic solvent which can be utilized in the workplace, in home and in labs. Around 6.7 million tons are produced annually as a solvent and in the manufacturing of methyl methacrylate and bisphenol. In organic chemistry, it is a common building block. Acetone is not a volatile compound. It can be found in variety of products such as nail polish remover and paint thinner. It is produced by human body's normal metabolic processes. Thermocol beads mixed with Acetone and the mixed product is shown in the Figure 2. Cement mortar is a composite which is used extensively in masonry work, plastering, restoring damaged concrete, patching or filling, rendering, flooring and the production of precast products. The expanded polystyrene beads are

**Figure 2:** Thermocol beads mixed with Acetone

**Table 1:** Comparing the Behaviour of EPS Adhesive Mortar and Cement Mortar

| S. No | Test | Days | On Cement mortar in KN/mm$^2$ | On EPS Adhesive in KN/mm$^2$ |
|---|---|---|---|---|
| 1 | Compressive Test | 7 | 267.75 | 154.17 |
| | | 14 | 263.61 | 204.96 |
| | | 28 | 338.84 | 227.81 |
| 2 | Bonding Strength Test | 7 | 6.4 | 6 |
| | | 14 | 4.2 | 4.2 |
| | | 28 | 3.0 | 3.0 |
| 3 | Split Tensile Test | 7 | 122 | 12 |
| | | 14 | 193 | 17 |
| | | 28 | 206 | 27 |
| 4 | Water Absorption Test | 28 | 0.4% | 0.27% |

partially dissolving in the acetone within a one second and fully dissolved in the acetone within 5min. This expanded polystyrene adhesive is applied on brickwork as a binder. Compressive test, Bonding Strength test, Split Tensile test and Water Absorption test on EPS adhesive mortar and cement mortar carried out as per IS 3495. The test results on specimens after 7, 14 and 28 days are compared with a table and shown in the Table number 1.

## 5. Conclusion

Scarcity of cement raw materials forced for replacing materials such as expanded polystyrene waste. Usage of expanded polystyrene waste reduces the environmental pollution and lead eco-friendly nature. The expanded polystyrene beads got fully dissolved in the organic solvent acetone. The expanded polystyrene beads dissolve in acetone lead mortar and can be applied on brick masonry. While dissolving the expanded polystyrene in organic solvent- acetone there is no harmful gas released. The characteristics of expanded polystyrene mortar are compared with the cement mortar. In the expanded polystyrene mortar outer layer is not healed which reduces the compressive strength and Split tensile strength compared to cement mortar. The expanded polystyrene does not absorb much water and water enters only on pores which show it is water resistant. Though the results of the expanded polystyrene mortar are lesser than the cement mortar it can be used in non-load bearing walls and un-important structures. As a scope, usage of sand in the expanded polystyrene mortar may perform well compared to the cement mortar.

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