Experimental Investigation on Heat Resistive Paints

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Abstract:

Emerging new trends of construction methods sometimes cause detrimental effects in the environment though they are helpful to mankind. Also in the current situation rise in temperature at global level has been the furthermost issue due to which there is an increase in use of electrical energy in order to maintain constant room temperature. This led to concept of green building by which energy is managed effectively. One of the concepts of green building is cool roof by which the room temperature is reduced. This resulted in the development of heat resistive paints with locally available materials which can be applied to the surface of the roof. Use of locally available material in paint makes it cost effective apart from being resistive to heat waves or rays from sun. The paint which was developed was tested in terms of paint properties like density, viscosity, drying time, temperature, impact and impression test. Initially for temperature testing degree of reflection over a painted surface was observed. Finally a model room was constructed and painted on the roof and the room temperature was observed.

Keywords: *green building, heat resistive paint, temperature, impact, impression*

I. INTRODUCTION

Increasing globalization and industrialization have contributed to rise in global temperature which in turn significantly increased the temperature of residential areas. It is well-known that the state Tamil Nadu in India is in tropical region. Summer heat is increasing every day and many cities in India record temperatures above 100-110 ^{o}F (37.8-43.3 ^{o}C) or even higher. Typically most of the construction in Tamil Nadu, India incorporates flat roofs with brown roof tiles through which sun's rays can penetrate into living rooms. Many people, especially babies and the elderly, suffer from heat-related illnesses like perspiration, exhaustion, fever, difficulty in urination, collapse, and sometimes death due to high heat. In order to overcome heat the use of electronic devices such as electronic fans, air-conditioner, air-coolers, etc are increasing in numbers. Though these devices maintain lower room temperature than atmospheric temperature certain electronic devices like air-conditioner liberate gases like chlorofluorocarbon which is hazardous to ozone layer and in turn it affects living community of earth. On the other hand these electronic devices are not at affordable cost to low income people. Generally black colour absorbs heat whereas white colour reflects heat. Thus a white coloured paint prevents the sun rays entering the living room.

II. LITERATURE REVIEW

Thorat et .al [2013] study revealed that silicone is so effective that some degree of thermal resistance can be achieved simply by cold blending ten percent or more of a silicone resin with a conventional binder. The temperatures that such a coating will resist are limited to approximately 220°C.Copolymerization, even with modest levels of silicone resins, is more efficient, and can be achieved with, for example, alkyds, phenolics, epoxies, acrylics and saturated polyesters. A heat resistant paint prepared from the epoxy and silicon resins which can withstand temperature up to 500 °C. The paint can be apply on external/ internal surfaces of the Heat exchangers, steam pipes, chimneys, pipes ,reactors, boilers, evaporators , inner coatings for autoclaves, furnaces etc.

Sekar et. al [2012] studied the importance of providing the room comfort by means of Solar Reflective Paint (SRP) on the roof and thereby reducing the consumption of electrical energy. The temperature of the living room was brought down considerably of about 7°C by implementing the solar reflecting paint on the roof top. A 3D Model of 25 m^2 (Air conditioned room) was developed using ANSYS 13. All the parameters such as physical properties of air, thermal properties of roof material, solar reflective paint and the insulation below roof were taken into consideration.

Michelle van Tijen and Rebecca Cohen [2008] concluded that green buildings incorporate many strategies to reduce energy use and environmental impacts and improve occupant health. Cool roofs are one important green building strategy because of the immense positive benefit they can provide The elevated temperatures can impact communities by increasing peak energy demand, air conditioning costs, air pollution levels and smog formation, and heat-related illnesses. Cool roofs can help reduce the negative effects of heat islands by reflecting the heat back to the atmosphere.

Bingtao Tang, et al [2013] found that the heat resistance of polymethylmethacrylate (PMMA) photonic crystal films has been the major challenge for its applications in displays or paints. In this strategy, the heat resistance was controlled and remarkably improved by introducing methacrylic acid as co-monomer together with methyl methacrylate. The heat resistance of PMMA films that have a bright structural color is dramatically improved by using methacrylic acid as a co-monomer. The mechanism of improving the heat resistance of PMMA was investigated. PMMA photonic crystal films with 18.7 wt% MAA could resist high temperatures up to 160 ^{o}C.

Apurva Wadnerkar and Prof.Zamre,G.S. [2015] investigated high temperature protective coatings which provide higher protection to walls, prevent corrosion and rust formations, resist high temperatures and offer protection from irreparable damages. Coatings may be applied as liquids, gases or solids. A coating is a covering that is applied to the surface of an object, usually referred to as the substrate. The “hybrid” chemistry achieved by combining an aliphatic epoxy with a silicone resin allows the formation of a silicone-epoxy resin that performs better than an organic or inorganic polymer alone. This allows for a durable binder for the protective coatings industry.

Ananda Kumar,S. and Sankara Narayanan, T.S.N. [2002] dveoped a siliconized epoxy interpenetrating coating system using epoxy resin as base, hydroxyl-terminated poly-dimethylsiloxane (HTPDMS) as modifier, γ –amino propyltriethoxysilane (γ-APS) as crosslinking agent and dibutyltindi-laurate (DBTDL) as catalyst. Poly-amidoamine and aromatic polyamine adduct were used as curing agents for the above coating systems. The thermal behaviour, glass transition temperature (Tg) and morphological characteristics of unmodified epoxy and siliconized epoxy coating systems cured by poly-amido amine and aromatic polyamine adduct were studied using thermo-gravimetric analysis, differential scanning calorimetry and scanning electron microscopy, respectively, and the results are discussed. The thermal stability of epoxy coating systems is enhanced when siloxane is incorporated to them.

Nalathambi V, and Suresh G [2014] discussed tha applications of nano technology in the field of chemical engineering in developing paints that are anti corrosive and having good scratch and flame resistance.

As the complexity of environmental issues and construction methodologies increases day by day it has become necessary to develop materials which are effective in terms of sustainability, economy and energy. This led us to develop a paint which on application on the buildings can reduce the room temperature up to 10°C (approximately) by action of reflection.

A. Objectives

The objectives of the present investigation are as follows,

- To develop paint that reflects maximum heat from the roof top of a building.
- To develop low cost paint so that low income people can afford the paint.
- To reduce the usage of air-conditioner thereby managing the energy effectively.
- To use locally available and non-hazardous material as paint ingredients.

III. EXPERIMENTAL PROGRAM

A. Materials used

1) Lime

Calcium hydroxide, traditionally called slaked lime, is an inorganic compound with the chemical formula $Ca(OH)_2$. It is a colorless crystal or white powder and is obtained when calcium oxide is mixed, or "slaked" with water. Calcium hydroxide is used in many applications, including food preparation. Slaked lime is used as the base material for the paint.

2) White Cement

White Portland cement contains little or no iron or manganese, the substances that give conventional cement its gray color. IS 4082-1982 is the generally referred standard for white cement. White Portland cement is also used as base material in this experimental work.

3) Silica Powder (from waste glass)

The oldest type of glass is silicate glasses based on the chemical compound silica, the primary constituent of sand . The glass is composed of approximately 75% silicon dioxide (SiO_2) and the remaining 25% of sodium oxide (Na_2O) from sodium carbonate (Na_2CO_3), calcium oxide also called lime (CaO) and several minor additives. Waste glass is crushed into powder.

4) Fevicol

Fevicol is a adhesive. Fevicol MR is used for bonding paper, cardboard, thermocol, fabrics, wood, and plywood. Fevicol SH is a synthetic resin adhesive intended for wood working and various materials where one of the surfaces to be bonded is porous. Thus fevicol dry distemper liquid (DDL) is used as the binder in this paint.

*5) **Water***

Water that is clean and free from injurious amounts of oils, acids, alkalis, salt, sugar, organic materials or other substances that may be deleterious to concrete is used.

*6) **Primer***

A primer or undercoat is a preparatory coating done on the surface to be painted before painting. Priming ensures better adhesion of paint to the surface, increases paint durability, and provides additional protection for the material being painted.20%-30% synthetic resin, 60%-80% solvent and 2%-5% additive agent is the composition of paint.

B. Trial Mixes for Consistency

Initially Trial mixes were made using the basic ingredients such as Water, Lime and fevicol and checked for the consistency of the paint. Details of trial mixes adopted are shown in Table 1.Trial mixes were prepared by varying the lime content and the quantity of fevicol is taken as 10% by weight of lime. The best consistency was obtained for 1:0.1:1(Water: Fevicol: Lime).With this ratio as the base, lime is replaced by white cement and glass powder in various percentages and the mix ratios adopted for further investigation are given in Table 2.

Table 1: Trial Mixes for Consistency

Trial No.	Water	Fevicol	Lime
1	1	0.062	0.62
2	1	0.083	0.83
3	1	0.125	1.25
4	1	0.1	1

C. Tests and Procedure

Following are the tests carried out on different mix proportions: a) Density b) Viscosity c) Drying time and d) Surface Temperature. The density of paint is noted by weighing the sample taken in a container of known volume. The viscosity or flow resistance of paint is observed with help of the flow cup shown in Figure 1. A certain quantity of sample say 100 ml is taken and allowed to flow through the flow cup. The time taken is noted with the help of stop watch in seconds. Drying time is noted by painting the trial mix in the plywood as per IS 101 (Part 6 / Sec 1):1988 in single coat , double coats and triple coats with primer as a base coat to improve its adhesion property.The time taken for complete drying of the surface painted is noted with the help of stop watch in minutes.Surface temperature is observed by subjecting infrared thermometer to the painted surface of size 20cm×30cm as per IS101 (Part 6 / Sec 1):1988.The impact and impression test is carried out by dropping a load of 1 kg on the painted surface of size 20 cm x 30 cm.

Figure 1: Flow cup

Table 2: Mix Proportions

Mix ID	Water	Fevicol	Glass	White Cement	Lime
M1	1	0.1	0	0	1
M 2	1	0.1	0	1	0
M 3	1	0.1	0	0.50	0.50
M 4	1	0.1	0.15	0.85	0
M 5	1	0.1	0.15	0	0.85
M 6	1	0.1	0.15	0.60	0.25
M 7	1	0.1	0.15	0.25	0.60
M 8	1	0.1	0.15	0.50	0.35
M 9	1	0.1	0.15	0.35	0.50
M 10	1	0.1	0.15	0.45	0.40
M 11	1	0.1	0.15	0.40	0.45
M 12	1	0.1	0.15	0.55	0.30
M 13	1	0.1	0.15	0.65	0.20
M 14	1	0.1	0.15	0.70	0.15
M 15	1	0.1	0.15	0.75	0.10
M 16	1	0.1	0.15	0.80	0.05

IV. RESULTS AND DISCUSSION

A. Density & Viscosity

The density and viscosity values for various mix proportions of paint are tabulated in Table 3.From the test results it can be seen that the variation in density is not that much significant for different mixes. The mixes M6,M8, M10, M13, M15, M16 exhibited a maximum density of 0.493 g/cc. From the viscosity test results it can be observed that the mix M5 that contains no white cement is less viscous and in general the mixes having higher quantities of white cement as compared to the quantity of lime are highly viscous in nature.

Table 3: Density and Viscosity

Mix ID	Density in gm/cm^3	Viscosity in seconds
M1	0.428	26
M 2	0.458	35
M 3	0.455	30
M 4	0.411	36
M 5	0.470	25
M 6	0.493	35
M 7	0.484	26
M 8	0.493	35
M 9	0.480	27
M 10	0.493	27
M 11	0.480	28
M 12	0.448	36
M 13	0.493	36
M 14	0.444	36
M 15	0.493	37
M 16	0.493	37

B. Drying time

The drying time was observed for different mix ratios with the number of coats increased from one to three as shown in Figure 2. As the number of coats increases, the drying time also increases whereas the contents of white cement and lime do not have any influence over the drying time which was witnessed by the test observations. The painted surface with one coat took about 5 minutes to dry, surface with two coats took about 10 minutes to dry and surface with three coats required about 15 minutes for complete drying. The drying time is almost same for all the mixes.

C. Impact and Impression test

The impact and impression test was carried out for all the mixes for single, double and triple coats and from the test results it was inferred that no cracking or blistering was noticed due to a fall of 1 kg weight from a height of 50cm.

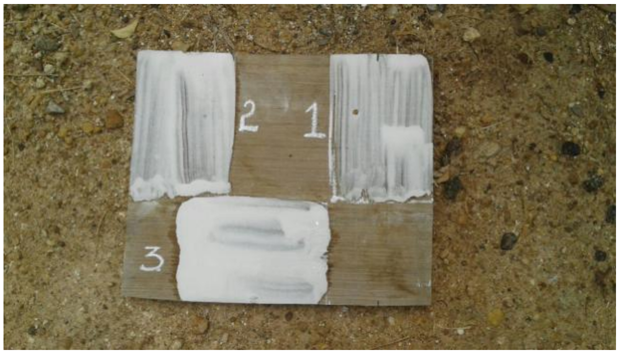

Figure 2: Drying time test

D. Surface temperature

Surface temperature of the painted surface was measured by using infrared thermometer. The temperature was measured on the painted surface of size 20cm×30cm. Temperature was measured at three different timings morning at 10.00 a.m., afternoon at 12.30 p.m. and 3.00 p.m. on the same day and the results are tabulated in Table 4, Table 5 and Table 6 respectively. From the results it can be seen that the mix M8 performs better which can be realized by the maximum degree of reflection for 3 coats.

Table 4: Surface Temperature at 10.00 a.m.

Mix ID.	Temperature in ^oC				Degree of reflection for 3 coats
	Uncoated surface	Single coat	2 coats	3 coats	
M1	37	35	34	33	4
M2	38	36	34	32	6
M3	39	38	36	34	5
M4	39	37	36	35	4
M5	40	38	36	34	6
M6	38	36	35	33	5
M7	39	38	37	35	4
M8	**43**	**41**	**39**	**36**	**7**
M9	41	40	39	36	5
M10	36	35	34	31	5
M11	41	39	38	36	5
M12	39	38	37	34	5
M13	36	35	34	33	3
M14	36	34	33	33	3
M15	38	35	34	33	5
M16	38	36	34	32	6

Table 5: Surface Temperature at 12.30 p.m

Mix ID.	Temperature in ^{o}C				Degree of reflection for 3 coats
	Uncoated surface	Single coat	2 coats	3 coats	
M1	48	45	43	37	11
M2	48	46	44	38	10
M3	46	44	43	38	8
M4	50	47	45	40	10
M5	51	50	47	39	12
M6	49	47	45	39	10
M7	50	48	46	40	10
M8	**52**	**50**	**49**	**39**	**13**
M9	50	47	45	39	11
M10	50	48	45	39	11
M11	50	49	46	39	11
M12	49	47	45	39	10
M13	44	40	39	38	6
M14	45	43	40	39	6
M15	50	48	44	40	10
M16	49	47	45	39	10

Table 6: Surface Temperature at 3.00 p.m

Mix ID.	Temperature in ^{o}C				Degree of reflection for 3 coats
	Uncoated surface	Single coat	2 coats	3 coats	
M1	40	38	36	34	6
M2	39	36	35	33	3
M3	37	35	34	33	4
M4	38	37	36	35	3
M5	40	38	37	35	5
M6	39	37	35	34	3
M7	39	38	36	35	4
M8	**40**	**37**	**35**	**33**	**7**
M9	41	38	35	34	7
M10	38	35	33	32	7
M11	39	38	37	36	3
M12	37	36	35	33	4
M13	37	36	35	34	3
M14	36	35	34	33	3
M15	37	36	35	33	4
M16	39	38	36	34	5

E. Model Study For Real Time Application

A model room with dimension 50cm × 50cm × 50cm was constructed as shown in Figure 3 and Figure 4 with a Reinforced Concrete (RC) roof slab of thickness 50mm.Plastering was also carried out around the brick wall. Two rooms were built in order to have a comparison between painted and unpainted RC slab. For one of the rooms, the slab was left unpainted and for the other room the slab was painted with the mix M8. The mix was applied onto the slab in single, double and three coats and the room temperature was measured using a thermometer and the results are given in Table 7. From the results it can be found that a reduction in room temperature of about 6^{o}C, 8^{o}C and 9^{o}C was noticed for single coat, double coats and three coats respectively as compared to the temperature of the room with unpainted slab. This clearly reveals that the paint developed is effective in reducing the room temperature by a considerable amount.

Figure 3: Model room during construction

Figure 4: Model room with RC slab

Table 7: Room temperature

Mix ID.	Number of coats	Room Temperature	
		Room with unpainted slab	Room with painted Slab
M 8	1	40	34
	2	40	32
	3	40	31

F. *Cost Analysis*

The cost effectiveness was estimated by comparing the cost of the commercially available heat resistant paint with that of the paint developed using fevicol, glass powder, white cement and lime. The cost of paint for $1m^2$ was estimated to be Rs.45 for commercial paints and Rs.18 for the paint developed. Hence the cost savings resulted is about 60%.

V. CONCLUSIONS

The objective of this investigation is to produce heat reflective paint with locally available materials which are not hazardous and energy efficient. About 20 trial mixes were prepared using fevicol, lime, white cement and glass powder. The properties of paint namely density, viscosity, drying time, surface temperature, impact and impression were studied for various trial mixes considered. From the test results the mix with 50% of white cement, 35% of lime, 15% of glass powder was found be the best in terms of their properties. The mix also showed good resistance to both heat and water when compared to other trial mixes. To demonstrate the real time application of this paint, a model room of size 50cm x 50cm was constructed and the room temperature was observed after coating the slab with the paint developed. The paint produced using lime, white cement and glass powder can be applied on the buildings which can reduce the room temperature up to 10°C by action of reflection.

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