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COMPARATIVE STUDY ON INHERENT THERMAL RESISTANCE OF NATURAL STONES AS TILES AND BLOCKS WITH ARTIFICAL TILES AND BLOCKS

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Abstract— ***Building area expose to sunlight or increasing temperature has demanded for more cooling system. So multidimensional path can be followed by using natural stone as tiles and blocks in construction. Use of natural stone will help to reduce the energy consumption, increasing level of global warming and will maintain the interior floors and walls of room cool. Property such as thermal conductivity, resistivity and diffusivity and other characteristics of a natural stone become an important factor in selecting them in construction purpose. Natural stone can have minimal carbon footprint in construction and multidimensional development. The naturally available and economic material can be used to partially replace the artificial product which harms the environment. Natural stone used in construction purpose were studied and their thermal properties were calculated by using thermostatic oven and infra red thermometer and result was manipulated with cement and ceramics tiles and blocks.***

Keywords— ***Natural Stone, Thermal Resistivity, Thermal Diffusivity, Thermal Conductivity, Thermostatic Oven, Infrared Thermometer***

INTRODUCTION

Temperature of room is increasing due to increase in level of global warming. 30 to 40% of all energy worldwide is used in building. India is becoming one of major energy consumer in the world and its energy consumption rate will be growing 4.2% year by 2035. Currently in market ceramic tiles and concrete blocks is practiced a lot. Concrete is most use or consumed material by man next to water. But cement – the key ingredient in concrete has carved much of our built environment has developed massive carbon footprint. India ranks second behind china for CO^2 emission from cement process. Also studies say that concrete realizes CO^2 that is a greenhouse gas and performing pivoted role in global warming. So we can use natural stone because of its good heat resisting property, hardness, strength and aesthetical appearances. Replacing concrete material is not possible but we can use natural stones as tiles and blocks wherever possible. And if economy is the point then it will get cheaper and cheaper when human will use it more commonly, best example is mobile, in 90s the rate of mobile where so high but as the use of mobile in human became common it became cheap and cheaper. Natural stones and cement ceramic tiles samples were investigated regarding their thermal resistivity, conductivity and diffusivity by using infrared thermometer and thermostatic oven.

Heat transfer or quantity of heat is described as transfer of energy from the material. The quantity of heat transfer depends on many factors such as porosity, shape, mineral composition and texture of rock. The inherent thermal resistance property of natural stone is a significant way in saving energy. The empirical formula, Fourier law of conduction was used to calculate the heat transfer and is expressed as

$$q = -kA\Delta T$$

where, q is heat transfer, k is conductivity, A is area and ΔT is temperature difference. The evaluation of thermal resistivity, conductivity and diffusivity of samples were measured and calculated by using infrared thermometer and thermostatic oven as stated in literature.

MATERIAL, INSTRUMENT AND METHOD

Ten stone samples such as marble, granite, laterite and basalt, representing the natural stones of India, with different properties and formation mechanism were selected. And five samples of cement and ceramic tiles were collected. Four marble sample such as white marble, red marble, green marble and black marble, from Rajasthan and Madhya Pradesh; Four granite sample such as black granite, red granite, pink grey granite and grey granite from Rajasthan; Basalt from Maharashtra and laterite from western coast of India were collected and characterized with respect to physical and chemical properties. All samples were dimensioned as 10x11x2 centimetres to accurately compare the thermal performance. The difference in porosity and structural matrix were the main parameters in determination of sample types.

The experimental setup simply includes thermostatic oven and infrared thermometer. Infrared thermometer infers temperature from a portion of the thermal radiation sometimes called black body radiation emitted by the object being measured. Device measured the temperature from distance by using laser hence also called as laser thermometer. The amount of infrared energy emitted by the object and its emissivity, the object's temperature can often be determined within the range of its actual temperature. Design essentially consists of a lens to focus the infrared thermal radiation on to a detector; this device converts the radiant power to an electrical signal that can be displayed in units of temperature. Infrared thermometer works on black body radiation, according to which any material with a temperature above absolute zero has molecule moving within it. Higher the temperature faster the molecule moves. The molecules emit infrared radiation as they move, and emit more radiation, including visible light, as they get hotter. This is why a heated metal emits a red or white glow. Infrared thermometers detect and measure this radiation. Thermostatic oven is electrical device that uses dry heat to sterilize the material also known as hot air oven. Thermostat is used to control the temperature. Double-walled design of the unit and an automated control system ensure the homogenous heat and the precise sequence of operation as well as quick recovery time after door opening. An air circulating fans helps in uniform distribution of the heat. A complete cycle involves heating the oven to the required temperature, maintaining that temperature for the proper time interval for that temperature, turning the machine off and cooling the articles in the closed oven till they reach room temperature.

In testing, samples were heated in oven at a constant temperature and at different voltage (60v, 80v, 100v) and the temperature gain by the sample was recorded at time interval of 25min. Also samples were heated for two different temperature and temperature gain by the sample were recorded in time interval of 20mins.

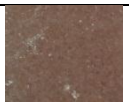
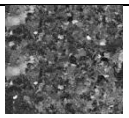
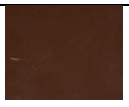
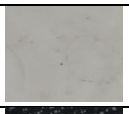
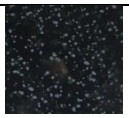
TABLE I

SPECIFICATION OF THERMOSTATIC OVEN AND INFRARED THERMOMETER

Thermostatic oven	
Temperature range	5°C above ambient to 250°C
Temperature accuracy	±1°C
Supply	240V, 50 Hz
Safety thermostat	Stand by Thermostat cuts off heater if temperature over-shoots
Insulation	Fibre glass wool.
Infrared thermometer	
Temperature range	-30°C to 500° (-22°F to 932°F)
Accuracy	±1.5°C
Response time	< 500 ms(95% of reading)
Emissivity	0.10 to 1.00
Optical resolution	10:1 (calculated at 90% energy)
Display resolution:	0.1°C (0.2°F)
Battery life	10 hours with laser and backlight on
Operating temperature	0°C to 50°C (32°F to 122°F)
Size	175 x 85 x 75 mm (6.88 x 3.34 x 2.95 in)

TABLE II

INFORMATION OF SAMPLES USED IN PROJECT WORK

Samples	**Information**	
Natural Stone	**Sources Of Natural Stone**	
White marble	Rajasthan state (Makrana Marble)	
Red marble	Rajasthan state(Jaipur)	
Green marble	Rajasthan state(Udaipur)	
Black marble	Rajasthan state(Abu Black)	
Black granite	Rajasthan state, Andhra Pradesh state	
Red granite	Karnataka state, Orissa state, Tamilnadu state	
Pink granite	Karnataka state (Llkal, Bagalkot District)	
Grey granite	Rajasthan state, Tamilnadu state, Andhra Pradesh state	
Laterite	Western Coast Of India (Konkan Region)	
Basalt	Maharashtra state	
Artificial Tiles	**Types of Artificial Tiles**	
Sample 1	Encaustic cement tile	
Sample 2	Cement tile	
Sample 3	Ceramic tile	
Sample 4	Cement tiles	
Sample 5	Ceramic tile	

TESTING AND OBSERVATION

First, temperature of sample was recorded at room temperature and then the samples were placed in thermostatic oven at constant temperature of 50˚C and at different voltage i.e. at 60v, 80v, 100v and temperature again by the samples were recorded by infrared thermometer in time interval of 25mins. Three reading were taken of each samples and then mean temperature was noted.

TABLE III

TEMPERATURE READING OF SAMPLES RECORDED AT 50˚C CONSTANT TEMPERATURE AND AT DIFFERENT VOLTAGE WITHIN TIME INTERVAL OF 25MINS.

Sr. no	Sample of tiles and rock	At room temperature (28.5° c)	At 50° c (constant)		After 25 min
			60V	80V	100V
1	White marble	29.6	60.8	76.8	78.3
2	Pink marble	29.5	57.7	74.25	78.2
3	Green marble	28.9	56.25	72.15	77.05
4	Black marble	29.4	58.55	71.15	84
5	Black granite	30.1	65.5	72	71
6	Red granite	29.9	54	77.75	85
7	Grey granite	29.07	76.55	77.95	81
8	Pink granite	28.9	73.5	69.7	75
9	Laterite	24.8	57.4	70.7	74
10	Basalt	29.44	59.4	89	90
	Artificial tiles				
11	Sample 1	29.5	65.5	77.1	82
12	Sample 2	29.7	63.9	77.4	82.2
13	Sample 3	29.6	64.8	76.7	82.2
14	Sample 4	29.3	67.1	78.9	85.3
15	Sample 5	29.6	62.6	74.5	80

Similarly again temperature of samples were taken at room temperature and then samples were heated two time for first time at 50˚C constant temperature , the temperature gain in sample was noted after time interval of 20mins. And for second time again at 80˚c constant temperature, temperature gain in sample was noted after time interval of 20mins. Here to three reading of each sample were taken and then the mean temperature was noted. Also our project group made a visit to nearby structure where natural stone were used and measured the temperature of room and the stone use with respect to surrounding temperature. And it was observed that temperature of natural stone tiles used construction showed less temperature than surrounding temperature or can say inner wall and floor showed less temperature with respect to outside temperature. Following observation was done and graphs were plotted. Mean temperature was taken after recording the reading. And with this recorded temperature thermal resistivity, conductivity and diffusivity of the samples were calculated

TABLE IV

TEMPERATURE READING OF SAMPLES AT 50˚C AND 80˚C CONSTANT TEMPERATURE

Sr. No	Sample name	Room temperature (31.5˚C)	At 50˚C constant temperature	At 80˚C constant temperature
1	Marble	30.53	53.13	73.46
2	Granite	30.21	51.7	73.25
3	laterite	30.05	47	74.8
4	Basalt	30.50	53.67	80.5
5	Artificial tiles	30.9	53.37	78.2

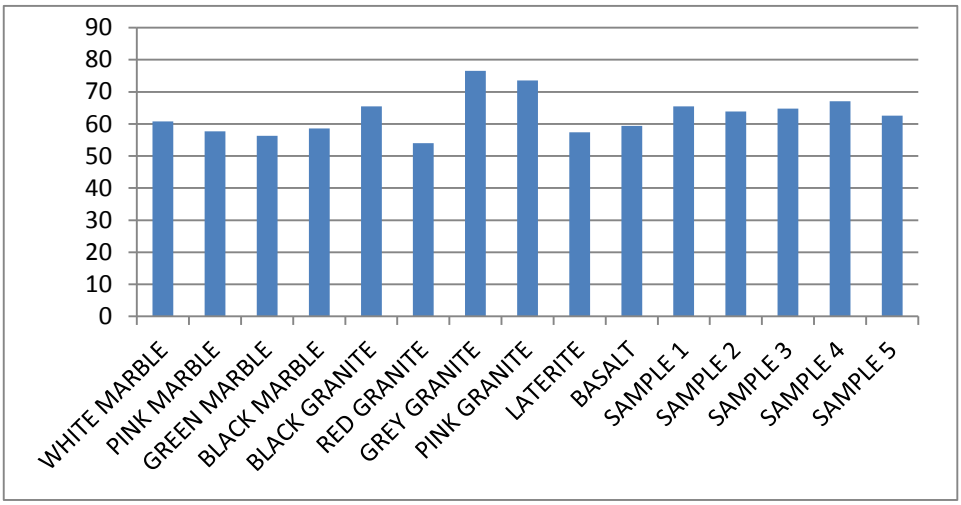


Fig. 1 at constant temperature of 50˚c against 60 volts temperature of samples

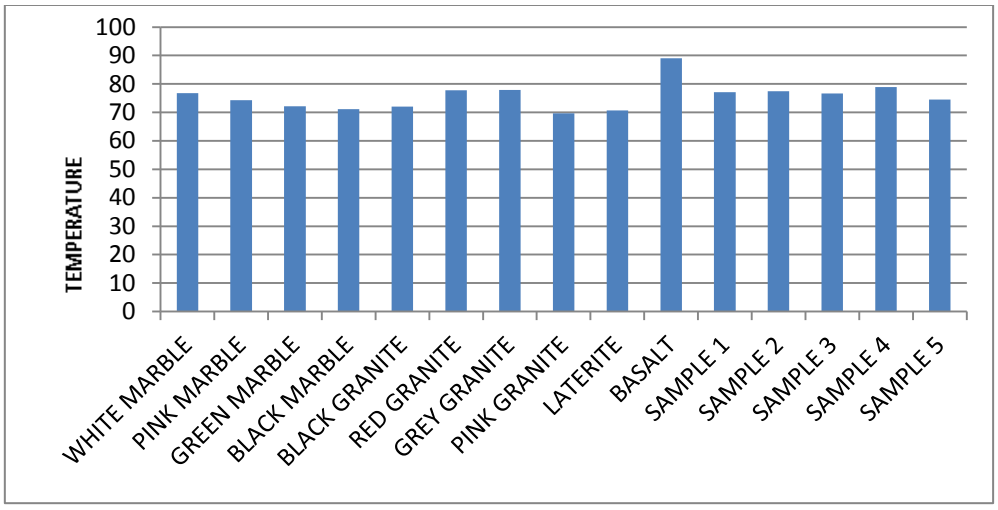


Fig. 2 at constant temperature of 50˚c against 80 volts temperature of samples

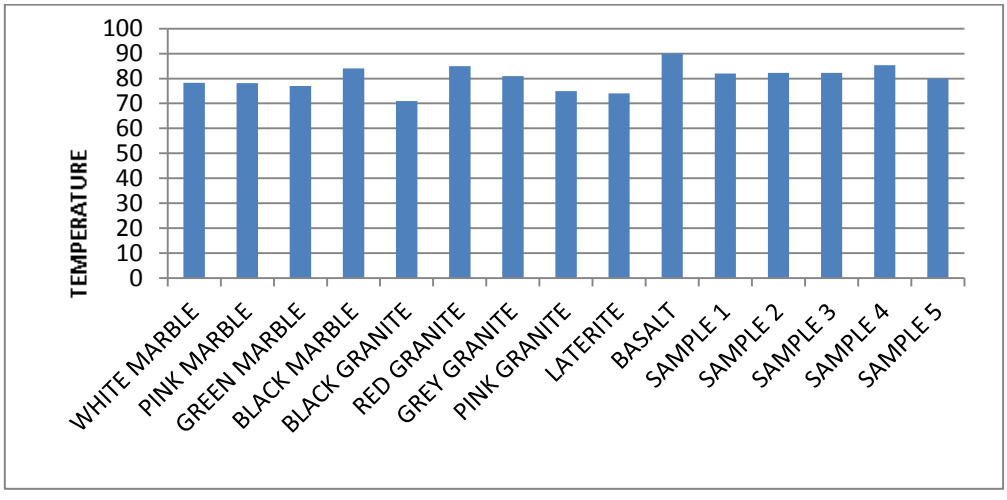


Fig. 3 at constant temperature of 50˚c against 100 volts temperature of samples

RESULT

From the above observation the quantity of heat of each sample were calculated. Further taking dimension and temperature difference with quantity of heat, thermal conductivity resistivity and diffusivity were estimated. All the values were manipulated with earlier estimated values stated in research paper and IS code. And the values we estimated in results were satisfying. From the tested fifteen samples conductivity of granite and laterite appeared less than marble, basalt and cement and ceramic tiles. Laterite and granite proved to have more resistivity than marble, basalt and cement and ceramic tiles. Thermal Diffusivity that is rate of transfer of heat of a material from the hot end to cold end , it is more in cement and ceramic tiles and laterite has the least diffusivity followed by basalt, granite and marble. And graph of estimated values was plotted.

TABLE V

SAMPLES THERMAL CONDUCTIVITY, THERMAL RESISTIVITY AND THERMAL DIFFUSIVITY

Sr. no	Sample name	Thermal Conductivity W/mk	Thermal Resistivity mk/W	Thermal Diffusivity m^2/s
1	White marble	2.145	0.46	0.90
2	Pink marble	2.145	0.46	0.90
3	Green marble	2.147	0.46	0.90
4	Black marble	2.150	0.46	0.91
5	Black granite	1.931	0.517	0.90
6	Red granite	1.930	0.518	0.90
7	Grey granite	1.930	0.517	0.90
8	Pink granite	1.930	0.518	0.90
9	Laterite	1.83	0.549	0.31
10	Basalt	2.05	0.48	0.8
	Artificial tiles			
11	Sample 1	2.44	0.40	1.63
12	Sample 2	2.44	0.40	1.63
13	Sample 3	2.446	0.40	1.63
14	Sample 4	2.435	0.41	1.63
15	Sample 5	2.44	0.40	1.63

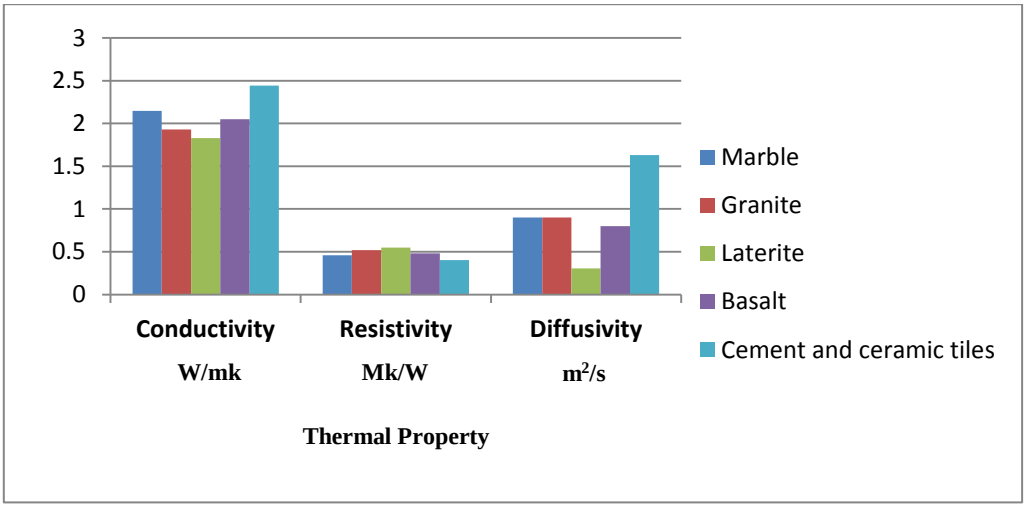


Fig. 4 thermal conductivity, resistivity and diffusivity of tested samples

V. CONCLUSION

Natural stones thermal performance should be studied accurately to avoid energy wasting in building. Fifteen samples including ten of natural stone tiles and five of cement and ceramic tiles of India with different formation mechanism and origin were investigated regarding their thermal conductivity, resistivity and diffusivity by infrared thermometer and thermostatic oven. The samples were subjected to 50˚C constant temperature and at different voltage of 60v, 80v, 100v, the temperature gain by the samples were measured three times at time interval of 25mins. For second time samples were subjected to two different constant temperature 50˚C and 80˚C and temperature gain by samples were checked three times at time interval of 20mins. Both times mean temperature was noted for each sample.

The highest thermal resistivity was determined in granite and laterite having high porosity and low thermal conductivity. Granite showed high resistivity due to it porous structure and percentage of silica present in it. Laterite showed high resistivity due to its porous structure and percentage of quartz present in it. Basalt showed slightly low resistivity than granite and laterite due to having less porous structure and less amount of silica but has low diffusivity than granite due to its ability of storing heat. Marble showed less resistance to heat than granite due its thermal conductivity slightly high than granite. Cement and ceramic tiles posses less resistance to heat due to it high thermal diffusivity and thermal conductivity proving that natural stone tiles are better than cement and ceramic tiles in resisting heat. Hence natural stone as tiles and blocks shows more resistance to heat and can be used in construction for flooring, cladding and wall construction so to keep the interior room cool or can say to control the room temperature.

Hence infrared thermometer and thermostatic oven can be efficiently used to determine rocks thermal property i.e. thermal conductivity, thermal resistivity and thermal diffusivity by applying it with physical and chemical characteristic results and empirical formula's calculation.

VI. ACKNOWLEDGEMENT

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