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A Computational Model Based Study To Control The Flow Of Heat Radiation From The Sun In Reinforce Concrete Slab

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Abstract
It has been found from the past studies approximately 30% heat is getting transferred inside the buildings through the concrete slab. In this research, an attempt is made to study and identify a suitable heat controlling barrier in the RC slab. The study aims to find the heat flow through the RC slab into the building by constructing two RC slabs with different heat guarding techniques and one slab as control unit. Slab 1 without weathering course (Without WC – control unit), Slab 2 with weathering course (with WC), Slab 3 with barrier made of air transient layer as heat barrier (Hollow pipe). Initially, a computation study was carried using COMSOL 4.3 a FEM based soft tool to find the thickness and location of air transient layer to provide in RC slab 3. The slabs were kept in ambient environment and day temperatures were measured at six different time slots (8 am, 11 am, 01 pm, 03 pm and 06 pm) in different depths in the slab (0.2 mm to 0.8 mm from bottom). Based on the data collected for about six weeks the suitable heat controlling barrier in RC slab was identified and reported.
Keywords: Heat; RC slab; Weathering Course (WC); COMSOL 4.3.

1. INTRODUCTION

Around the globe, Asian countries are the most humid areas, which experience high intensity of heat radiation from the Sun. The temperature peaks at 38ºC. Abnormal temperature variation in the Earth's climatic structure is marked as Global warming. Global warming openly means an increase in global ambient temperature. This occurrence broadly triumphs the arctic and Antarctic hemispheres, where the drift of hot air into the external space of frozen water will activate the icebergs to disintegrate, which raises the Mean Sea Level (MSL) of the continents. Since 1980, worldwide temperature has increased by 0.3 percent in 2013, which has increased up to 0.8%. According to NASA's Earth Observatory stationery report, worldwide temperatures will three-way the rate of the present state in the coming quarter. Space science and climatic investigators say that CO2 is the main gas for global warming, and highly potent gases like chlorofluorocarbons increase global warming. Greenhouse gases are the primary catalyst of warming, in which this gas enter the upper atmospheric layer called ozone and puncture unsolicited holes, from these holes injurious radiation straight hits the air and surface of Earth, which leads to abnormal warming of Earth. Additionally, it disturbs the structural terrace and increases its transient radiation, resulting in a high concentration of heat inside the building. It strikes the room temperature of the building and leads to the usage of air conditioning machines, and this triggers the electrical consumption. NASA's Goddard Institute for Space Studies led James Hansen and his team to undertake research on the global climatic system in 1967. Around the 1970s, some scientists concluded that the Earth was entering a period of global cooling. Time's prior, the Brilliant Serbian mathematician "Milutin Milankovitch" has elucidated how our biosphere warms and cools jaggedly in a 100,000-year cycle due to its slowly changing orbit relative to the sun. Milankovitch's theory suggested Earth should be just starting to head into its subsequent ice age. The surface temperature facts collected by Mitchell appeared to agree; the record showed that Earth experienced a period of cooling (by about 0.3ºC) from 1940 through 1970. Additionally, many scientists have displayed their outcomes and other findings displayed in 1975 by veerabhadran Ramanathan were more similar to the output produced by Hansen's. Ramanathan mentioned that manmade CFCs are a particular compound for greenhouse gases with as much as 200 times the heat-absorbing capacity of CO2. People were releasing CFCs to the lower troposphere at an increasing rate; Ramanathan expressed concern that these new gases would manifest the Earth's greenhouse effect and cause our world to warm.

2. RESEARCH SIGNIFICANCE

The present study aims to experiment with the rate of heat flow through the concrete roof slab and identify an alternate way to control the same (Fig. 1). Further, conventional heat guarding techniques increase the construction cost and time. To overcome this problem, an attempt is made to assess the role of the air transient layer in the RC slab as heat barrier. Initially, a computational model study was conducted with the aid of COMSOL 4.3 "Multiphysics software" to identify the location and thickness of the air transient layer in RC slabs (Figs 2 and 3). In addition, a comparative study was carried out with an experimental model and a computational model to identify the effectiveness of the data obtained from the model and real-time.

3. MATERIALS AND METHODS

3.1 Construction of RC Slabs

Initially three RC slabs were casted according to the dimension of 1 m X 1 m X 0.13 m (Fig. 1).

1. RC slab without weathering course (Without WC)
2. RC slab with weathering course (With WC)
3. RC slab with air transient layer (Hollow pipe)

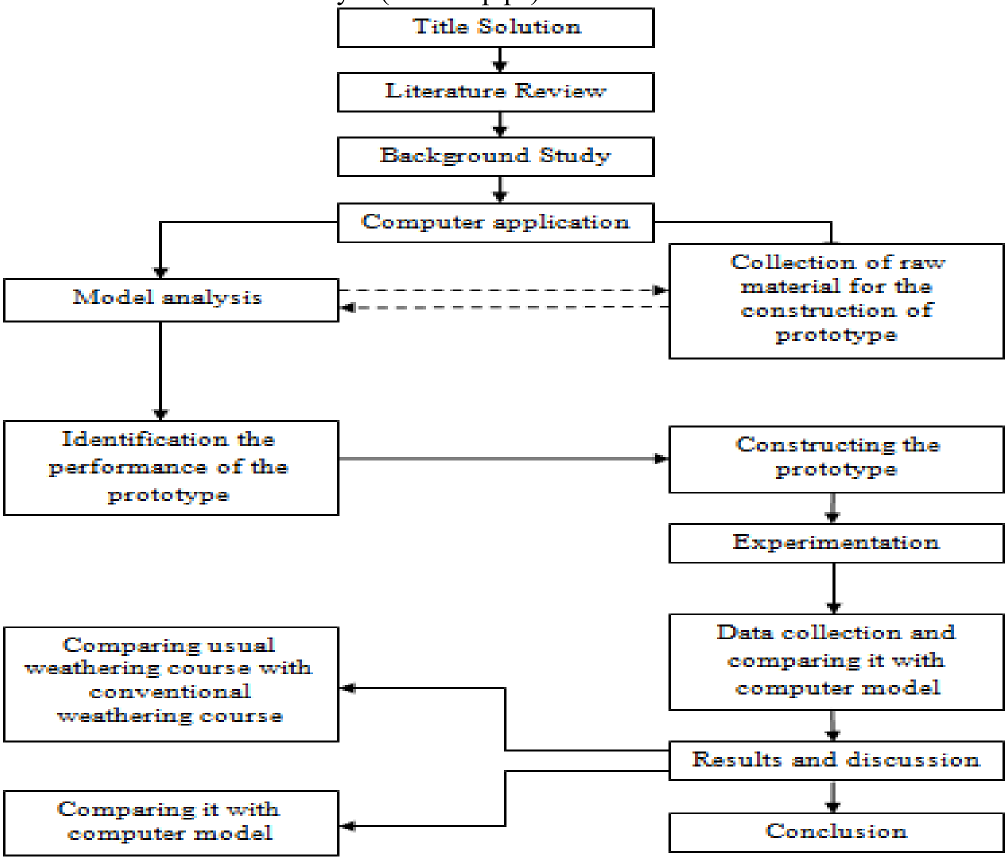

Fig 2 Flow diagram of the study

Table: 1. Raw materials required for a Slab fabrication

Materials	OPC	Fine Aggregate	Coarse Aggregate
Quantity (kg/m3)	50	100	150

The slabs were cast according to the mix ratio 1:2:3 as per IS 456:2012, with the mix proportion given in Table 1. In conventional buildings, weathering course is used to control the heat flow through the slab, which leads reduction of the indoor temperature of the buildings. Hence, to make a comparative study, out of three RC slabs, one slab was not guarded by weathering courses (Slab 1) which act as a control unit. The other was guarded by a weathering course (slab 2).

And in slab 3 to ensure the cross ventilation of ambient air over the top of the slab (air transient layer), a 12 m long PVC pipe with a 2.54 cm diameter was taken and cut into 12 pieces with a length of one meter each. The thickness and the diameter of the PVC pipe is determined by the result obtained from the computational study (Fig. 3 and 4). The fragmented pipes were positioned on the top of the roof slab with 8 cm Center to center to cove the one meter distance in total (Fig. 4). Finally, to cover up the PVC pipes cement mortar is used as plasters for about a thickness of 5 cm and the slab was casted (Fig. 5).

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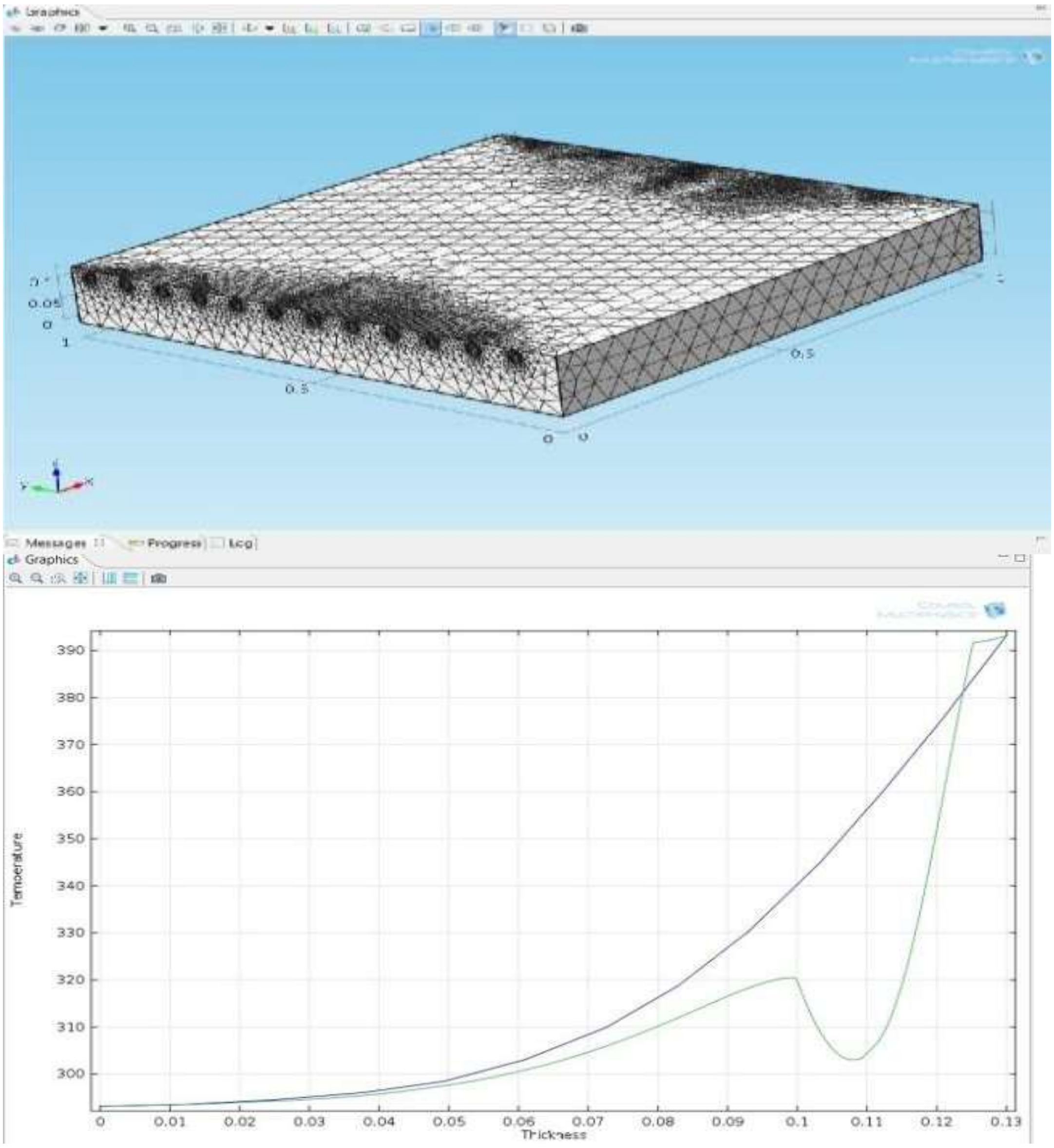

Fig 2 Computational model study

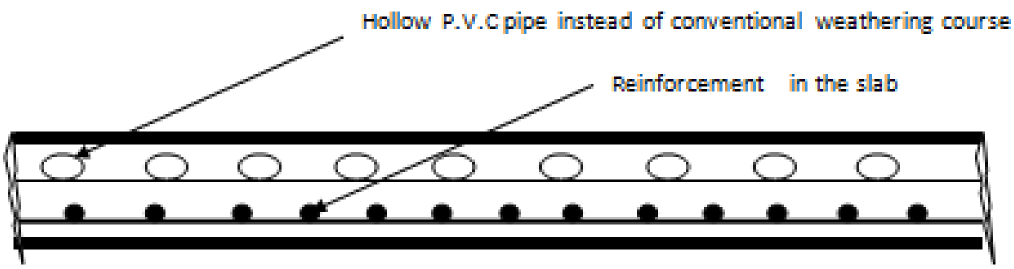

Fig 3 Cross section of RC slab 3 with provision for air flow

For performing the experimentation, all the fabricated RC slabs were mounted on a steel frame of height 2 m above the ground level. The sides of the frames were covered with heat-insulated sheets to measure the room temperature (RT). The temperatures were recorded during the day with six different time slots (8 am, 11 am, 01 pm, 03 pm, and 06 pm) and at various depths of slabs from bottom of the RC slabs - 0.2 mm to 0.8 mm (Fig. 6). To perform the comparative study, temperatures were measured at ambient (AT), room (RT), and on the surface of the slabs. A digital steel probed temperature measuring device (Digital Thermometer) was used to measure the temperatures for the study.

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Fig 4 RC slab with air transient layer

Fig 5 Fabricated RC slab

Fig 6 Slots to measure temperature in slabs

4. RESULTS AND DISCUSSION

The experiment results are represented graphically in Figures 7 and 8. The results reveal that the ambient (AT) and room temperature (RT) are well below the temperature recorded in the slabs.

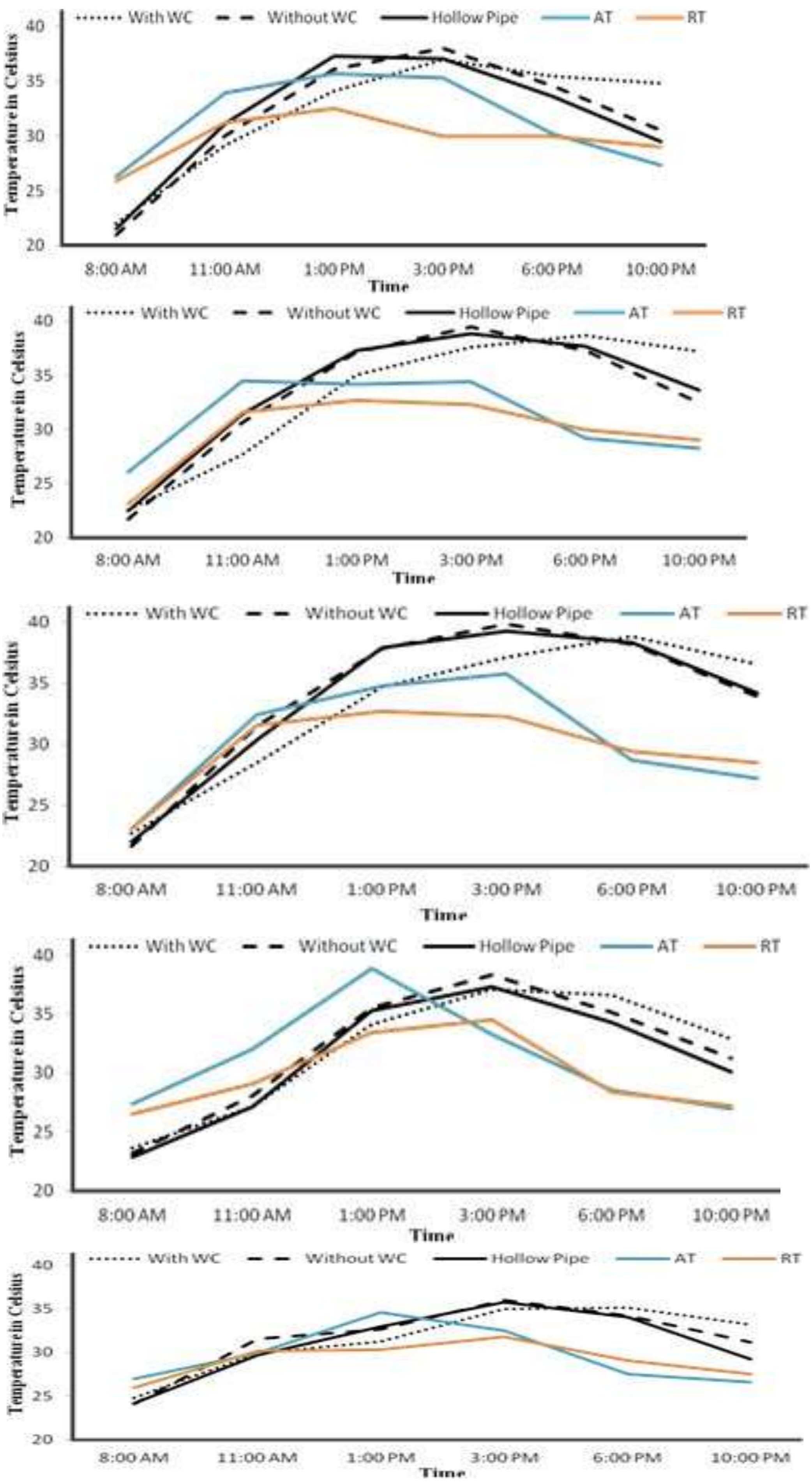

Fig. 7 Graphical representations of results (1-5 weeks)

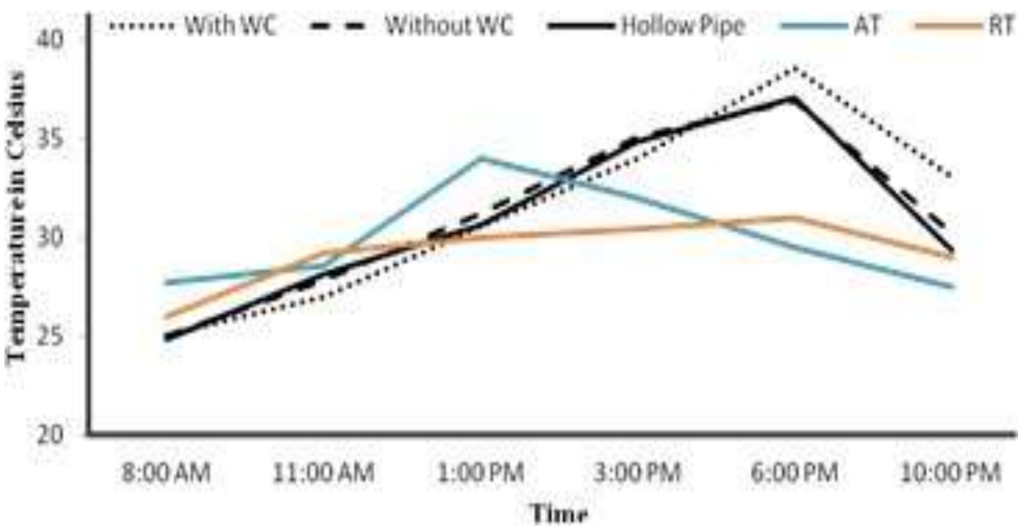

Fig. 8 Graphical representations of results (6th week)

This is due the heat absorbed by the course mass of concrete slab and in parallel the absorbed heat is not escaping from concrete mass in it.

4.1 Impact of Heat flow in RC Slabs

The minimum and maximum temperatures recorded in the model study are between 22º C and 42º C. To determine the performance of the slab concerning heat transformation, the ambient temperature and room temperature are also added to the graph. In all the measurements, the ambient temperature and the room temperature fall below the RC slab's temperature. This might be due to the shed provided by the slab. The minor temperature variation observed in the slabs may be due to the thermal stress experienced by them. The graphs (Figs. 7 and 8) pictures that the slab without a weathering course is not performing well, and approximately a 20-30 percent rise in temperature was recorded than the slab provided with heat barriers (Slabs 2 and 3). This evident that a barrier is required to resist the heat in RC slabs; hence, it is not practically advisable to go for a RC slab without any weathering course material or any heat guarding provisions.

4.2 Role of air transient layer as heat guarding

It was also observed from the results that the slab 3 provided with an air transient layer performs effectively in controlling the flow of heat through the RC slab. Notably, during the experimentation for the whole duration of the study, the temperature recorded in slab 3 was 10 -15% less when compared with the slab aided by weathering course (Slab 2) and 20 to 30% less without WC (Slab 1). This might be due to the cross-air circulation provision in slab 3. Hot air in the ambient environment reduces the air density inside the hollow pipe, which aids in circulating the air at a faster rate in the hollow pipe, provided in slab 3.

4.3 Comparative study with computational mode and experimented model

The bar diagram (Fig. 9) will give the average temperature recorded during experiments in the RC slabs at different depths.

The results obtained with the computation model show 10 to 15% variations with the experimental model and this may be due to the hindrance in field conditions and the boundary layer conditions adopted while using the soft tool. It was also observed during the study that slab 3, provided with an air transient layer as heat guarding system, is much efficient than the slab provided with weathering coarse (slab 2). This evident that the possibility of using this system in RC slabs is a good option to cool or reduce the flow of heat inside the building. On the other hand, adopting this type of heat guarding system will require careful examination while designing the slabs to meet the structural requirements. It was also observed from the study that providing a PVC pipe for air circulation is not advisable due to its durability in withstanding the thermal shocks or heat absorbed by the RC slab over time. Hence, a suitable alternate piping material has to be examined and adopted accordingly while using this technique.

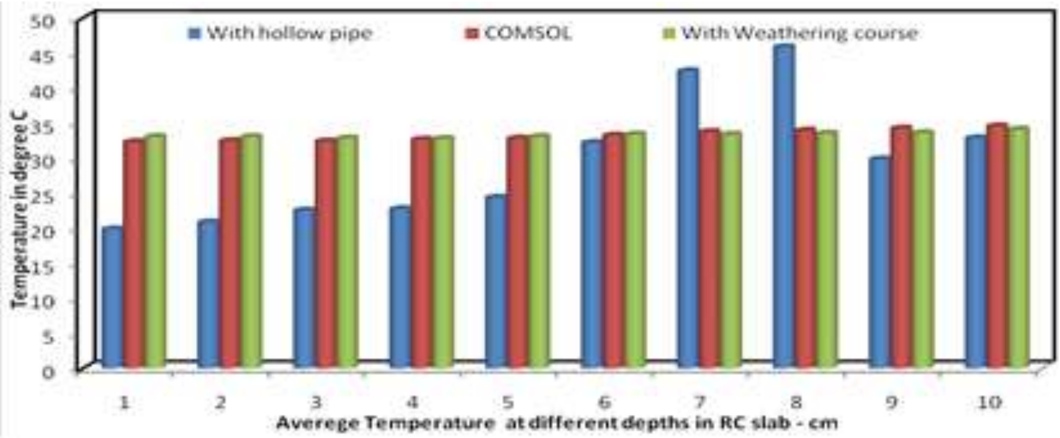

Fig 9 Comparative study with computational mode and Experimented model

In addition, to make air circulation faster inside the hollow pipe, experimentation is needed to study the effect of a forced air circulation system in the technique adopted in slab 3.

5. CONCLUSION

It was concluded from the present experimental study that the adoption of the air transient layer in RC slab is more effective in controlling the flow of the Sun's radiation. Moreover, the conventional method to control the heat transformation in RC slab is an expensive and time-consuming process (provision of weathering course). And also adapting this method in construction requires proper maintenance over a time. Hence, from the experimental findings, it was observed that adopting the air transient layer as a heat barrier in RC slab is more effective and economical. But, providing PVC pipe for air circulation is not advisable due to its durability in withstanding the thermal shocks or heat absorbed by the RC slab over time. In addition, during the structural design, care must be taken to avoid the formation of cracks during load transformation from the slab to other members of the structure. Holistically, it was concluded that the alternate method of heat guarding in RC slab can be adopted with proper structural design.

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