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EXPERIMENTAL ANALYSIS OF HEAT CONDUCTION THROUGH HOLLOW BUILDING BLOCKS

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Abstract:
Experimental investigation of heat transfer for solid and hollow concrete blocks with 2, and 3 evenly spaced cavities in them is explored to determine the most appropriate number of cavity in building blocks for effective energy consumption in building without compromising the strength of the blocks and building. The samples were tested based on their crushing strength and heat flow resistance. The results show that for the same block size, increasing the number of holes leads to a corresponding increase in the heat resistant value of the block without compromising it's physical strength greatly.

Keywords: Cavities; Experimental; Heat Transfer; Hollow Blocks.

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1. Introduction

The heat challenges inside a building had received a lot of attention, largely because it affects the comfort of human beings that may be inside such buildings and the general energy consumption requirement of such buildings.

The heat inflow and outflow to a building depends on the materials and the designs used in the construction of such building. A principal material used is the building blocks. Available on the market today are several kinds of bricks, with different dimensions, with or without cavities, made with clay, concrete or wood which are characterized by different thermal properties [5]. The most commonly used design has cavity inside the block; the size, shape, and number of cavities plays a vital part in the heat transfer that takes place between the surroundings and the room. This has therefore suggested the need to investigate the varieties of cavity options that can be explored to adequately minimize the energy requirement either for cooling or heating in a building.

In the south west part of Nigeria, hollow concrete blocks (HCB) are the most commonly used construction material, due to their lightweight, improved thermal and acoustic insulation characteristics.

The main factors that influence heat transfer in hollow concrete block walls are the size, position and shape of voids, the geometrical characteristics of the mortar joints and the thermal

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conductivities of the constituent materials [1]. Navaratnarajah et. al showed that a higher void cement hollow blocks offer the potential for energy savings, decreased raw material usage and reduced environmental impact [4]. Also Antar and Baig professed that an increase in the number of cavities in the layout of the block as well as the cavity layouts has a direct effect on reducing the heat flux without compromising the strength of the building block [2].

2. Preparation of Specimen

Solid and Hollow concrete blocks of size (450x225x225)mm Fig. 1-3, made using plane river sand with maximum size 4.75mm and specific gravity of 2.6 homogenously mixed with ordinary Portland cement of 43 grade confining to NIS 087: 2000 [3]. Each set of comparison block was produced from the same raw material and the same process in an effort to isolate the effect of void area on heat transfer and performance of the hollow blocks. The physical dimensions of the test solid concrete blocks (SCB) and hollow concrete blocks are shown in Table 1

Figure 1: SCB

Figure 2: HCB2H

Figure 3: HCB3H

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Table 1: Specimen Specification

	Specimen Type		
	SCB	**HCB2H**	**HCB3H**
Dimension (mm)	450x225x225	450x225x225	450x225x225
Web thickness (mm)	0	50.8	38.1
Face shell thickness (mm)	0	50.8	38.1
Void area (%)	0	37.04	44.44

3. Mechanical Strength of the Specimens

The mechanical strength of the specimens where experimentally investigated by considering the compressive/crushing strength of five (5) different specimens from each of the classes of blocks under investigation. The result is as shown in Table 2.

Table 2: Compressive Strength of Specimen

	Compressive Strength (N/mm)					
	Specimen 1	**Specimen 2**	**Specimen 3**	**Specimen 4**	**Specimen 5**	**Average**
SCB	4.63	5.52	4.60	4.92	4.61	4.856
HCB2H	3.53	3.48	3.42	3.42	3.44	3.458
HCB3H	3.01	2.90	2.95	3.31	2.80	2.994

4. Thermal Investigation

Many methods exist for the determination or measurement of thermal conductivity of a material, such as the steady-state (absolute or comparative) technique, the 3ɰ technique, and the thermal diffusivity measurement. Each of these techniques has its own advantages as well as its inherent limitations, with some techniques more appropriate to specific sample geometry [8].

The thermal conductivity for each of the samples was determined using the steady-state (absolute or comparative) method by measuring the temperature difference (ΔT) across the samples in response to an applied amount of heating power. This is essentially a measure of the heat flow through the sample. Given by the equation below

$$K = \frac{Q(dx)}{A(\Delta T)}$$

Where, Q is the heat transfer rate through the brick, dx is the thickness of the brick, A is the heat transfer area of the brick and ΔT is the temperature difference across the brick surfaces.

5. Results and Discussions

The recorded experimental values of the thermal conductivities of Specimens are as shown in table 3.

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Table 3: Thermal conductivities of Specimen

	Thermal conductivities ($Wm^{-1}K^{-1}$)					
	Specimen 1	**Specimen 2**	**Specimen 3**	**Specimen 4**	**Specimen 5**	**Average**
SCB	0.657	0.654	0.661	0.658	0.650	0.656
HCB2H	0.485	0.475	0.488	0.477	0.482	0.481
HCB3H	0.225	0.228	0.224	0.230	0.227	0.227

Considering the average values for the compressive strength of the specimens and the average values for the thermal conductivities of specimens it is observed that the physical strength of the concrete block decreases as the number of cavity is increased, while the thermal resistance increases. This makes it more difficult to effectively combine the two parameters in the selection of suitable concrete blocks for building construction.

6. Conclusions and Recommendations

Generally, a typical concrete block is much economical if it contains more number of cavities and better thermally efficient than when it has no cavity or the cavity size is reduced. The hollow concrete block with two cavities is preferred considering both strength and conduction resistance ability.

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Nomenclature

SCB	*Solid concrete block*
HCB2H	*Hollow concrete block with 2 cavities*
HCB3H	*Hollow concrete block with 3 cavities*
ΔT	*Temperature difference (K)*
K	*Thermal conductivities* ($Wm^{-1}k^{-1}$)
Q	*Heat transfer* (wm^{-2})
dx	*Sample thickness (m)*
A	*Sample cross sectional area* (m^2)

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