ENGINEERING

ISSN (Print): 24490954
ISSN (Online): 26364972

TIME-SAVING DESIGN AIDS FOR ONE-WAY HOLLOW SANDCRETE BLOCK SLAB

Nuruddeen Muhammad Musa

Civil Engineering Department, Kano University of Science and Technology, Wudil

Corresponding Email: mnuruddeen@gmail.com

Manuscript Received: 29/06/2018 Accepted: 08/08/2018 Published: December 2018

ABSTRACT

Although efficient computer programs are available for analysis and design of most structural systems, design aids are very important in engineering designs. This research study presents a time-saving design aids for one-way hollow sandcrete block slab. The slabs are designed to conform to the specifications of BS 8110, and are intended in design offices for preliminary designs and for checking computer results output.

Keywords: *Sandcrete blocks; one-way hollow slab; Design aids; Design moments;*

INTRODUCTION

Hollow block slabs are ribbed concrete slab formed typically using concrete or sandcrete blocks. These types of slabs, widely used throughout the world for many decades, are now becoming more and more popular in Nigeria too because of their technical and economic advantages when compared to the conventional solid concrete slabs, and with the absence of hollow pots in the market, sandcrete and concrete blocks becomes an alternative. Sandcrete blocks are the commonest and most popular masonry walling units in Nigeria (Abdullahi, 2005; Ewa and Ukpata, 2013). The principal advantage of these types of construction is the reduction in weight as much as 20 to 30% achieved by introduction of voids in the slab (Varghese, 2009). The blocks do not contribute to the strength of the slab; as a matter of fact it is an additional weight on the slab, therefore the lower the weight of the blocks the better. The design of concrete members in flexure normally ignores the tensile resistance of the concrete below the neutral axis. Hence, the concrete below the axis can be removed, since it is theoretically ineffective (Adel A. AI- Azzwi and Abbas J., 2017), although it serves the purposes of resisting the shearing force surrounding the reinforcement bars in tension and connecting the bars to the compression zone (Oyenuga, 2005). Other advantages include reduction of loads on foundation thereby allowing more storeys to be built on the same foundation, low reinforcement per square metre and high acoustic and thermal insulation.

Hollow block floors proved economic for spans of more than 5m with light or moderate live loads, such as hospitals, office or residential buildings. They are not suitable for structures having heavy live loads such as warehouses or parking garages (Ghoneim and El-Mihilmy, 2008). Hollow block slabs are classified into a one-way hollow block slabs and two-way hollow block slabs depending on the arrangement of the ribs on plan. One-way hollow slab are the most widely used in Nigeria and are the focus of this study. Fig. 1 shows a one-way hollow block slab in which the ribs are arranged in one direction. To avoid shear failure, the blocks are terminated near the support and replaced by solid parts. Solid parts are also made under partitions, brick walls and concentrated loads.

Structural design is an iterative process, with the initial design being the first step in the process. Though the various aspects of structural design are controlled by many codes and regulations, the structural engineer has to exercise caution and use his judgment in addition to calculations in the interpretation of the various provisions of the code to obtain an efficient and economic design. And as schedules becomes tighter and codes and standard becomes more complex, engineers need tools and design aids to assist them in producing safe, economical structures in the shortest time possible (Fanella, 2002). The advent of modern computer brings speed, efficiency and accuracy in analysis of structures (Rao and Babu, 2007), But to computerize the areas such as conceptual design requires great expertise. Therefore, the aim of this paper is to produce a timesaving aids for the design of hollow sandcrete slab. The design aid can be utilized in preliminary or final stages or to verify computer outputs and ensure they conform to BS standard (BS8110-1, 1997).

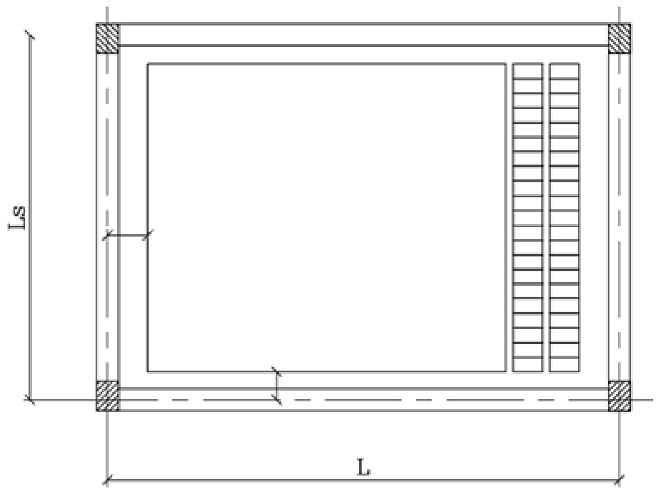

Figure 1: One-way hollow slab

One-way hollow block slab are frequently used in construction, and it is when the ribs are in one direction regardless of the rectangularity (ly/lx). The ribs are positioned in the shorter direction, thus all the loads are transferred in that direction. One way hollow block slab are best suited for spans between 5m to 7m. For any span greater than 7m, a two-way hollow block slab is recommended. Cross ribs are used when the live load ≥
3kN/m^2 or Span > 5m.

Fig 2: One-way hollow slab arrangement (sources: (Hosny, 2008)

When designing one way spanning hollow block slabs the following steps shall be followed:

Step 1: Dead load calculations

This will include the self-weight of the slabs and ribs. Characteristic superimposed loads due to screed, tiles etc. should be included. The dead loads are calculated based on the cross-section shown in Figure 3.

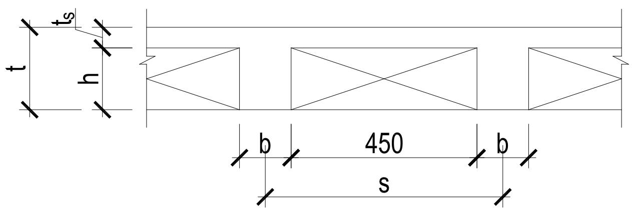

Figure 3: Hollow Sandcrete slab cross-section

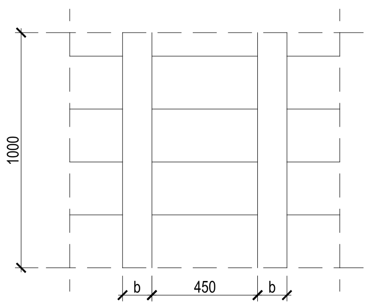

Figure 4: Hollow sandcrete slab plan

Dead Load (kN/m^2) = $t_s \gamma_c$ --- Slab topping
+ $2bh*\gamma_c/S$ -----Ribs
+5 (weight of one block)/S --- Blocks
+ Others --- finishes, screed etc

Step 2: Live Load calculations

The live load is obtained based on occupancy using the necessary code of practice BS 6399 (BSI, 1996)

Step 3: Ultimate design loads

The ultimate design load is calculated from: n = 1.4 (Dead load) + 1.6 (Live load)

Step 4: Design data

Before proceeding with calculations of moments, the design data are established, these include: strength of concrete (Fcu), strength of steel used (Fy), assumed diameter of the main steel and cover. Effective depth is then calculated.

Step 5: Bending moment at mid-span

The bending moment at mid-span for a simply supported span is calculated using the formula.

$M = nl^2/8$

While for continuous spans, coefficient from Table 3.12 of (BS8110-1, 1997) can be used to obtained the moments.

Step 6: Calculation of reinforcing steel at mid-span (Design as T-section)

Once M is calculated, then the following parameters are calculated: K, z = 0.95d (maximum), As and As min based on BS8110

Step 7: Deflection check

Deflection is checked at mid-span based on BS8110. Service stress fs need to be calculated. M/bd2, Modification ratio, Basic l/d shall be known, Permissible l/d calculated and Actual l/d calculated. For deflection criteria to be satisfied, the permissible l/d ratio shall be greater than the actual l/d ratio.

Step 10: Shear Check

Maximum shear from the support center-line shall be determined and the shear stress calculated using:

Shear stress = V/(bd) < 5Mpa or formula 8sqrt (fcu), 100As/bd From table 5.1 of BS8110, vc shall be determined.

MATERIALS AND METHODS

PARAMETRIC DESIGN OF ONE-WAY HOLLOW SANDCRETE SLAB

An excel program to design a one-way hollow sandcrete slab was used to perform a parametric design of a one-way hollow sandcrete slab. The following parameters were used:

Span = 3m to 7m

Finishes = 1.0 kN/m^2

Live Load = 1.5 kN/m^2 to 5.0 kN/m^2

Sandcrete block sizes = 150mm and 230mm thick blocks

Concrete topping = 50mm

Rib width = 125mm

Fcu = 25N/mm^2

Fy = 250 N/mm^2 and 410 N/mm^2

The slabs were designed for flexure and checked for shear and deflection in accordance with BS (BS8110-1, 1997).

RESULTS AND DISCUSSION

Based on the results obtained from the parametric design, Tables and design charts were developed. Figures 5 and 6, shows the result of live loads against the design moments at various spans. The design moment increases linearly with increase in both span and the live load. These charts can be used effectively to estimate design moment for preliminary design and software checks.

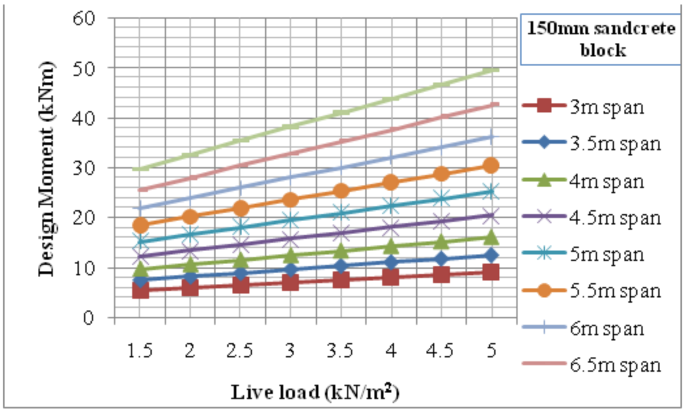

Figure 5: Live loads against Design Moment for 150mm sandcrete blocks

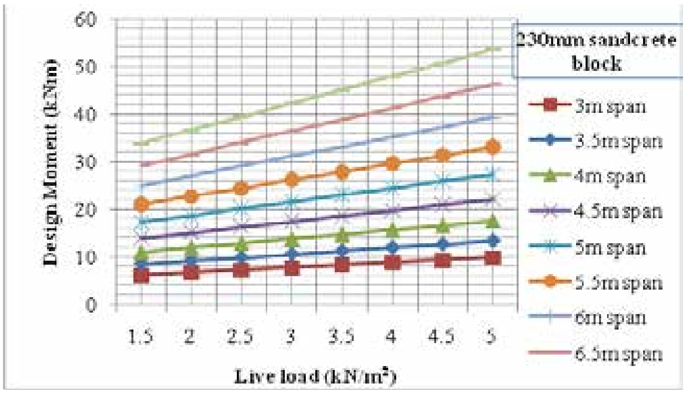

Figure 6: Live loads against Design Moment for 230mm sandcrete blocks

In a similar way, Figures 7 and 8, show the variation of span against the design moments at various live loads. Here also, the design moment increases linearly with increase in both span and the live load. These charts are included to assist designers in optimizing spans of hollow sandcrete block slab during design.

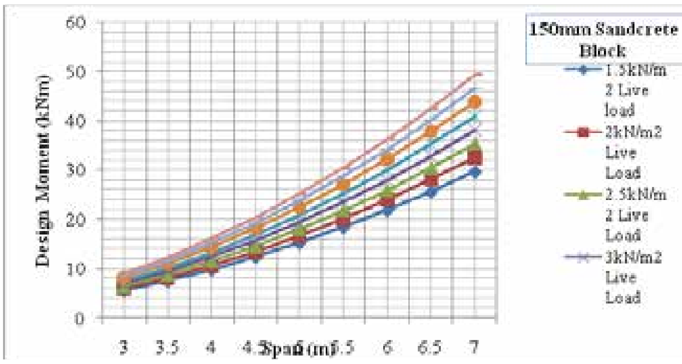

Figure 7: Span against Design Moment for 150mm sandcrete blocks

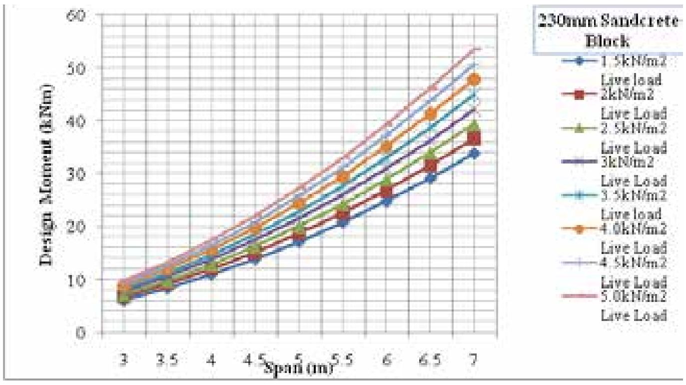

Figure 8: Span against Design Moment for 230mm sandcrete blocks

In Figure 9, variation of design moment against reinforcement ratio is presented. This chart can be used to estimate the reinforcement required from the design moment obtained from Figures 7 to 8 or from other analytical method. The reinforcement ratio increases linearly with increase in the design moment.

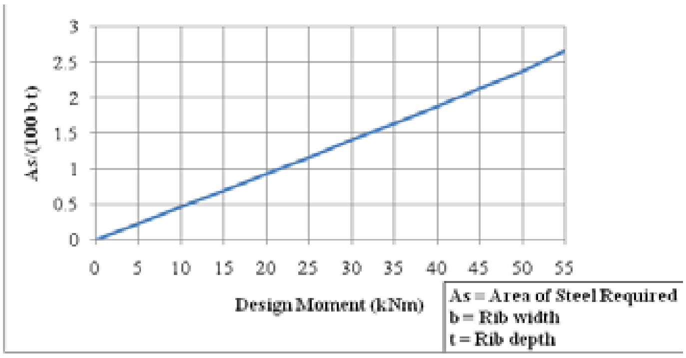

Figure 9: Design Moment against reinforcement ratio

To obtain the area of reinforcement required based on the parameters used in 3.0; Figures 10 and 11 are presented. The figures show the variation of span against the area of steel required at various live loads. Similarly, Tables 1 and 2 can be utilized for the same purpose.

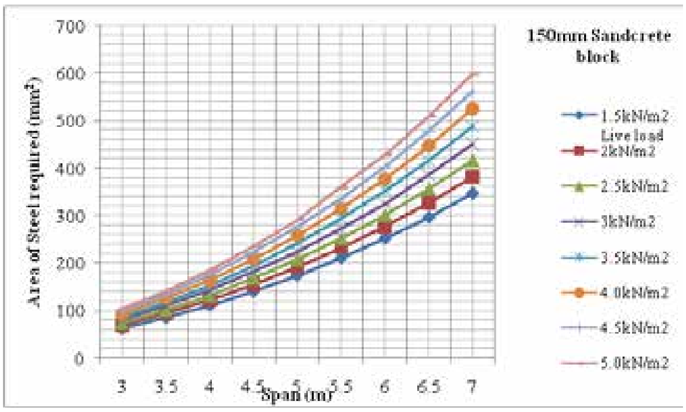

Figure 10: Span against Area of steel required for 150mm sandcrete blocks

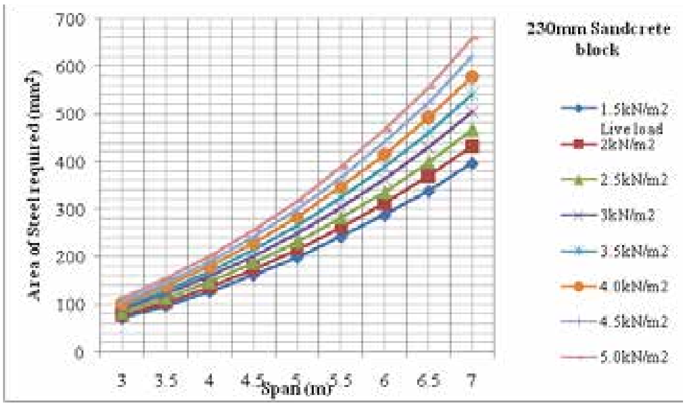

Figure 11: Span against Area of steel required for 230mm sandcrete blocks

Table 1: Minimum reinforcements required for the ribs of 150mm sandcrete blocks slab

S.No	SPAN (m)	Topping (mm)	Block height (mm)	Rib Width (mm)	Rib Depth (mm)	Imposed Load (KN/m2)	Minimum Reinforcement Required
1	3	50	230	125	280	1.5	2 Y10
2	3	50	230	125	280	2	2Y10
3	3	50	230	125	280	2.5	2Y10
4	3	50	230	125	280	3	2Y10
5	3	50	230	125	280	3.5	2Y10
6	3	50	230	125	280	4	2 Y10
7	3	50	230	125	280	4.5	2 Y10
8	3	50	230	125	280	5	2 Y10
9	3.5	50	230	125	280	1.5	2 Y10
10	3.5	50	230	125	280	2	2 Y10
11	3.5	50	230	125	280	2.5	2 Y10
12	3.5	50	230	125	280	3	2 Y10
13	3.5	50	230	125	280	3.5	2 Y10
14	3.5	50	230	125	280	4	2 Y10
15	3.5	50	230	125	280	4.5	2 Y10
16	3.5	50	230	125	280	5	2 Y10
17	4	50	230	125	280	1.5	2 Y10
18	4	50	230	125	280	2	2 Y10
19	4	50	230	125	280	2.5	2 Y10
20	4	50	230	125	280	3	3 Y10
21	4	50	230	125	280	3.5	3 Y10
22	4	50	230	125	280	4	3 Y10
23	4	50	230	125	280	4.5	3 Y10
24	4	50	230	125	280	5	3 Y10
25	4.5	50	230	125	280	1.5	3 Y10
26	4.5	50	230	125	280	2	3 Y10
27	4.5	50	230	125	280	2.5	3 Y10
28	4.5	50	230	125	280	3	3 Y10
29	4.5	50	230	125	280	3.5	3 Y10
30	4.5	50	230	125	280	4	3 Y10
31	4.5	50	230	125	280	4.5	3 Y12
32	4.5	50	230	125	280	5	3 Y12
33	5	50	230	125	280	1.5	3 Y10
34	5	50	230	125	280	2	3 Y10
35	5	50	230	125	280	2.5	3 Y10

36	5	50	230	125	280	3	3	Y12
37	5	50	230	125	280	3.5	3	Y12
38	5	50	230	125	280	4	3	Y12
39	5	50	230	125	280	4.5	3	Y12
40	5	50	230	125	280	5	3	Y12
41	5.5	50	230	125	280	1.5	3	Y12
42	5.5	50	230	125	280	2	3	Y12
43	5.5	50	230	125	280	2.5	3	Y12
44	5.5	50	230	125	280	3	3	Y12
45	5.5	50	230	125	280	3.5	3	Y12
46	5.5	50	230	125	280	4	2	Y16
47	5.5	50	230	125	280	4.5	2	Y16
48	5.5	50	230	125	280	5	2	Y16
49	6	50	230	125	280	1.5	3	Y12
50	6	50	230	125	280	2	3	Y12
51	6	50	230	125	280	2.5	3	Y12
52	6	50	230	125	280	3	2	Y16
53	6	50	230	125	280	3.5	2	Y16
54	6	50	230	125	280	4	3	Y16
55	6	50	230	125	280	4.5	3	Y16
56	6	50	230	125	280	5	3	Y16
57	6.5	50	230	125	280	1.5	3	Y12
58	6.5	50	230	125	280	2	2	Y16
59	6.5	50	230	125	280	2.5	2	Y16
60	6.5	50	230	125	280	3	3	Y16
61	6.5	50	230	125	280	3.5	3	Y16
62	6.5	50	230	125	280	4	3	Y16
63	6.5	50	230	125	280	4.5	3	Y16
64	6.5	50	230	125	280	5	3	Y16
65	7	50	230	125	280	1.5	2	Y16
66	7	50	230	125	280	2	3	Y16
67	7	50	230	125	280	2.5	3	Y16
68	7	50	230	125	280	3	3	Y16
69	7	50	230	125	280	3.5	3	Y16
70	7	50	230	125	280	4	3	Y16
71	7	50	230	125	280	4.5	3	Y20
72	7	50	230	125	280	5	3	Y20

Table 2: Minimum reinforcements required for the ribs of 230mm sandcrete blocks slab

S.No	SPAN (m)	Topping (mm)	Block height (mm)	Rib Width (mm)	Rib Depth (mm)	Imposed Load (KN/m^2)	Minimum Reinforcement Required	
1	3	50	230	125	200	1.5	2	Y10
2	3	50	230	125	200	2	2	Y10
3	3	50	230	125	200	2.5	2	Y10
4	3	50	230	125	200	3	2	Y10
5	3	50	230	125	200	3.5	2	Y10
6	3	50	230	125	200	4	2	Y10
7	3	50	230	125	200	4.5	2	Y10
8	3	50	230	125	200	5	2	Y10
9	3.5	50	230	125	200	1.5	2	Y10

10	3.5	50	230	125	200	2	2	Y10
11	3.5	50	230	125	200	2.5	2	Y10
12	3.5	50	230	125	200	3	2	Y10
13	3.5	50	230	125	200	3.5	2	Y10
14	3.5	50	230	125	200	4	2	Y10
15	3.5	50	230	125	200	4.5	2	Y10
16	3.5	50	230	125	200	5	2	Y10
17	4	50	230	125	200	1.5	2	Y10
18	4	50	230	125	200	2	2	Y10
19	4	50	230	125	200	2.5	2	Y10
20	4	50	230	125	200	3	2	Y10
21	4	50	230	125	200	3.5	2	Y10
22	4	50	230	125	200	4	3	Y10
23	4	50	230	125	200	4.5	3	Y10
24	4	50	230	125	200	5	3	Y10
25	4.5	50	230	125	200	1.5	2	Y10
26	4.5	50	230	125	200	2	2	Y10
27	4.5	50	230	125	200	2.5	3	Y10
28	4.5	50	230	125	200	3	3	Y10
29	4.5	50	230	125	200	3.5	3	Y10
30	4.5	50	230	125	200	4	3	Y10
31	4.5	50	230	125	200	4.5	3	Y10
32	4.5	50	230	125	200	5	3	Y12
33	5	50	230	125	200	1.5	3	Y10
34	5	50	230	125	200	2	3	Y10
35	5	50	230	125	200	2.5	3	Y10
36	5	50	230	125	200	3	3	Y10
37	5	50	230	125	200	3.5	3	Y12
38	5	50	230	125	200	4	3	Y12
39	5	50	230	125	200	4.5	3	Y12
40	5	50	230	125	200	5	3	Y12
41	5.5	50	230	125	200	1.5	3	Y10
42	5.5	50	230	125	200	2	3	Y10
43	5.5	50	230	125	200	2.5	3	Y12
44	5.5	50	230	125	200	3	3	Y12
45	5.5	50	230	125	200	3.5	3	Y12
46	5.5	50	230	125	200	4	3	Y12
47	5.5	50	230	125	200	4.5	3	Y12
48	5.5	50	230	125	200	5	2	Y16
49	6	50	230	125	200	1.5	3	Y12
50	6	50	230	125	200	2	3	Y12
51	6	50	230	125	200	2.5	3	Y12
52	6	50	230	125	200	3	3	Y12
53	6	50	230	125	200	3.5	2	Y16
54	6	50	230	125	200	4	2	Y16
55	6	50	230	125	200	4.5	3	Y16
56	6	50	230	125	200	5	3	Y16
57	6.5	50	230	125	200	1.5	3	Y12

58	6.5	50	230	125	200	2	3	Y12
59	6.5	50	230	125	200	2.5	2	Y16
60	6.5	50	230	125	200	3	2	Y16
61	6.5	50	230	125	200	3.5	3	Y16
62	6.5	50	230	125	200	4	3	Y16
63	6.5	50	230	125	200	4.5	3	Y16
64	6.5	50	230	125	200	5	3	Y16
65	7	50	230	125	200	1.5	2	Y16
66	7	50	230	125	200	2	2	Y16
67	7	50	230	125	200	2.5	3	Y16
68	7	50	230	125	200	3	3	Y16
69	7	50	230	125	200	3.5	3	Y16
70	7	50	230	125	200	4	3	Y16
71	7	50	230	125	200	4.5	3	Y16
72	7	50	230	125	200	5	3	Y16

CONCLUSION

The aids for the design of one-way hollow sandcrete slab presented in this research paper with the charts developed based on the provision of BS8110 can be used to significantly decrease design time and enhance quick check on software results.

REFERENCES

Abdullahi, M. (2005). Compressive strength of sandcrete blocks in Bosso and Shiroro areas of Minna, Nigeria. AU JT, 9(2), 126-131.

Adel A. AI- Azzwi and Abbas J., AL-Asdi. (2017). Nonlinear behavior of one way reinforced concrete hollow block slabs. *ARPN Journal of Engineering and Applied Sciences, 12(No.5)*, 1679-1691.

BS8110-1. (1997). Structural use of concrete —Part 1: Code of practice for design and construction.

BSI, BS. (1996). 6399-1, Loading for buildings. Code of practice for dead and imposed loads. BSI, London, UK.

Ewa, DE, & Ukpata, JO. (2013). Investigation of the compressive strengths of commercial sandcrete blocks in Calabar Nigeria. *International Journal of Engineering and Technology, 3(4)*, 477-482.

Fanella, David A. (2002). Time Saving Design Aids for Reinforced Concrete. Paper presented at the SEAOC 2002, 71st Annual Convention Proceedings.

Ghoneim, Mashour, & El-Mihilmy, Mahmoud. (2008). Design of Reinforced Concrete Structures. Cairo University.

Hosny, Ayman Hussein. (2008). Hollow block slabs. Reinforced concrete Lecture Notes, . Ain Shams University.

Oyenuga, Victor O. (2005). Simplified reinforced concrete design. ASTROS Limited, Lagos, Nigeria.

Rao, H Sudarsana, & Babu, B Ramesh. (2007). Hybrid neural network model for the design of beam subjected to bending and shear. Sadhana, 32(5).

Varghese, PC. (2009). Advanced reinforced concrete design: PHI Learning Pvt. Ltd.