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Quality Assurance Measurement of Sandcrete Hollow Blocks Manufactured in Ado-Ekiti, Ekiti State, South Western Nigeria

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Abstract

Quality assurance measurement of a Sandcrete hollow block of Ado –Ekiti environs was evaluated. The township was zoned into five Zones; where four block industries were randomly selected per zone. A total of two hundred blocks were sampled from twenty block producing industries within the five zones. The study began with the digitization of the Ekiti state map, tests such as Bulk density, Absorption test, Compressive strength, Abrasion test and Impact test were carried out on the sampled blocks. Compressive strength results from the sampled blocks varied between 1.03 and 0.63N/mm^2, 0.60 and 0.30N/mm^2, 0.50 and 0.28N/mm^2, 1.16 and 0.73N/mm^2, 1.63 and 1.45 N/mm for Zones 1-5 and sample 1-4 respectively. Water absorption test result varied between 13.2% and 15.4%, and 13 and 16.5, 14% and 15.8%, 13.6% and 16.4 ,09 and 13.5% for zone 1-5 and sample 1-4, respectively. The results showed that as the strength increases, the absorption values also decrease. The analysis showed that the abrasion results varied between 40 and 65%, 40 and 75%, 48 and 95%, 40 and 88%, 30 and 46% for zone 1-5 and sample 1-4 respectively. Impact test also varied between 50 and 85%, 45 and 94%, 55 and 96%, 47 and 93% ,35 and 46 for zone 1-5 and sample 1-4 respectively. The results indicated that, from all the zones evaluated, only zone 5 which comprises of sample 1, 2, 3 are within the range specified, while zones 1, 2, 3 and 4 were not found within stipulated range of 1: 8. It can be inferred that the blocks are not fit to be used for construction purposes. The use of sub-standard mix design should be discouraged among the block manufacturer within the study area.

Keywords: Abrasion, Compressive strength, Density, Sandcrete, Quality assurance, Zon

1. INTRODUCTION

Quality assurance and Quality control of sandcrete blocks are highly imperative to take cognizance of while examining building components, knowing how important housing is to a man for a living. Quality assurance and quality control will serve as the basis for measurement to regulate the irregularities in the Construction and building sector in Nigeria, which will also showcase the integrity of our expertise in the country. Sandcrete blocks are produced across Nigeria without a specific focus on the type of purpose its produced to suit. (Anosike, Oyebade 2012a). Building failures in Nigeran have caused several casualties in the country and leaving many citizens homeless. (S. Odeyemi, Anifowose et al. 2015). Sandcrete blocks remain inevitable in construction works, being a significant building material, it is appropriate that its superiority and strength be of principal interest to building contractors, and further handlers of buildings produced with them (Okafor, Egbe 2017). Concerns for sudden building failure in Nigeria requests that constituents used in the building of structures, houses, offices satisfy the least requirements. Housing is a necessity for man and the desire of individuals to own a nice-looking apartment is not luxury and highly inevitable (A. Odeyemi, Dada et al. 2010). Diverse construction Materials are used across the globe for different construction (Ajagbe, Ganiyu et al. 2013). Detached walls and building edifices with load comportment walls are commonly used in Nigeria due to the low cost of constructing it and easy to build.

Sandcrete skin plates and blocks can occasionally be used to afford aesthetic worth to buildings if it is well constructed, it could also be used to guild against moisture infiltration as well as wind act. Considering the efficacy of Sandcrete, the cost-effectiveness, and its ability to adjust to climatic influences is accountable for its wide application; particularly in small to medium structures in countries within humid rainforests where an extensive volume of precipitation and high average temperatures are highly intensive (Omoregie 2012). Nigerians mostly use Sandcrete blocks in fencing, structural outer walls of buildings which makes concrete blocks a very significant material in building construction (Baiden, Tuuli 2004). In relation to Nigeria Industrial standard- NIS 87:200, Sandcrete block is a compound material produced from the composition of several constituents which are cement, sand, water, cast into diverse sizes (Anosike, Oyebade 2012b). Sandcrete blocks can either be cast in solid or hollow rectangular forms. Sizes varies from 45cm X 22.5cm X 22.5cm (Hollow) for load comportment walls and 45cm X 15cm X 22.5cm (Hollow) for non-load comportment walls. The hollow blocks have a perforation that runs from upper part of the block to the bottommost end of it and occupies one-third of the size of the blocks. Solid Sandcrete block has no perforation in it. Figure 1 below illustrates sketches Sandcrete blocks, figure (a) illustrates Hollow Sandcrete block while figure (b) shows a clear picture of a solid Sandcrete block mainly used for load-bearing walls.

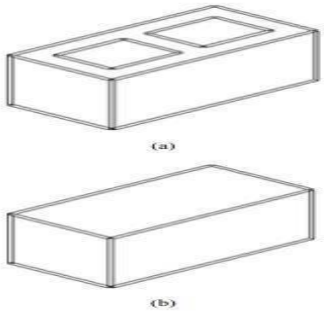

Figure 1. (a) Sandcrete block (Hollow type) (b) Sandcrete block (Solid)

Both Solid and Hollow concrete blocks are of different dimensions and weights which can be easily held by the builders making use of it, it has a facial shallow layer which is bigger than that of a brick but suitably dimensioned [Abdullahi,2005]. Sandcrete blocks have a high compressive strength which increases with density when it's fully dry. The least required strength of concrete stipulated in the Nigeria Industrial Standard NIS 87:2000 (Anosike, Oyebade 2012b) ranges between 1.5N/mm^2 to 2,5N/mm^2. The strength of concrete blocks varies due to different production methods used by individual producers, length of curing, sizes of blocks and properties of basic materials (Abdullahi 2005). Sandcrete blocks are comparatively affordable in relation to several other construction materials. Sandcrete blocks offer super resistance to mutilation without further incurring additional cost on preservation. Sandcrete blocks are highly resistant to rust, decay does not entail with constituents that are harmful to the environment (A. Odeyemi, Dada et al. 2010, S. Odeyemi 2012). Several factors are taken into consideration in the production of concrete blocks which are quality of the constituents, its mixing ratio, a technique adopted in mixing, molding process as well as the length of curing (Samson, Elinwa et al. 2002).

However, quality control and assurance of concrete block production must be a concern of all and as sundry since cases of building collapse is gradually becoming a phenonium in the southern part of Nigeria. it is time to take the bull by the horn, the block making industry is causing more harm in terms of block quality that will stand the test of time. This paper presents a study on quality assurance measurement of sandcrete hollow blocks manufactured in Ado-Ekiti, Ekiti State, South Western Nigeria. Sandcrete hollow blocks are more widely used among other walling materials in Ado-Ekiti and
Nigeria in general

2. MATERIALS AND METHODOLOGY

2.1 Study Area Location

Ado-Ekiti, which is the targeted area of this research is the capital of Ekiti State, South Western Nigeria. Ado Ekiti is located between latitudes 07^o 31^{1}and 07^o 49^1 north of the equator and longitude 05^o 27^1 east of the Greenwich Meridian. The area is readily accessible by a network of roads which also link the area with nearby towns. It has a total land area of about 180km^2. (Osuji et al 2018)

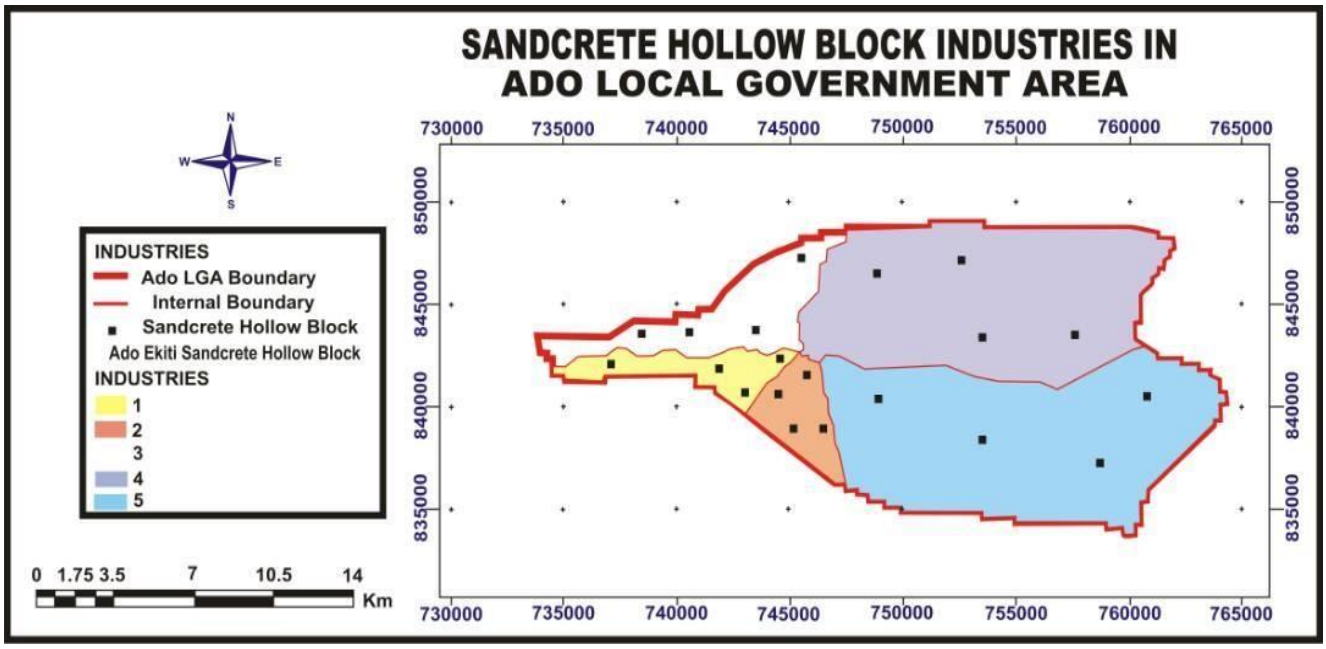

Figure: 2.0 Location of samples in Ado local government area map

2.2. Sample Collection

One hundred (100) sandcrete hollow blocks samples were purchased from the five major zone within 'the metropolis of AdoEkiti. Five pieces of blocks experimented and it was selected from the 20-block making factory already targeted initially in the listed zones. Six inches (6-inches) blocks of dimensions 450 x 225 from the block industries were taken to the laboratory and considered for quality assurance test in terms of water absorption and strength requirement Parameters. The date of cast and age of the block samples obtained were within 3 -14days. The study was conducted in the Peri-urban areas of Ado Ekiti, the capital town of Ekiti State of Nigeria (fig. 1). Five zones of the areas were air-marked viz; Housing road, Ado-Ijan road, Ado-Ikere road, Ado-Ilawe road and Ado-Iworoko road as ZONE 1, ZONE 2, ZONE 3, ZONE 4 and ZONE 5 respectively. The study began with the digitization of the Ekiti state map. Then, the geographic coordinate and other details using a Global Positioning System device (Arknava). The field survey was carried out by randomly selecting block manufacturing industries in Ado-Ekiti and its environs. Ado-Ekiti and its environs were considered due to the large volume of block manufacturing industries and being the capital of Ekiti State large volume of dwellings are required which involve the use of hollow sandcrete. The samples were labeled as follows:

Table1: Labelling of the Zones in Ado Ekiti

Zone1	Z1S1	Z1S2	Z1S3	Z1S4
Zone 2	Z2S1	Z2S2	Z2S3	Z2S4
Zone3	Z3S1	Z3S2	Z3S3	Z3S4
Zone4	Z4S1	Z4S2	Z4S3	Z4S4
Zone5	Z5S1	Z5S2	Z5S3	Z5S4

Table: 2.0 Sandcrete Hollow Block Samples Locations Co-ordinate

LOCATIONS	ELEVATIONS	EASTERN	NORTHERN	ACCURACY
ZONE 1 S1	464.1m	$007^{0}11.768^{1}$	$08^{0}37.910^{1}$	4.9m
ZONE 1 S2	391.8m	$007^{0}14.240^{1}$	$08^{0}39.734^{1}$	5.5m
ZONE 1 S3	412.9m	$007^{0}45.703^{1}$	$08^{0}43.473^{1}$	4.5m
ZONE 1 S4	436.8m	$007^{0}13.782^{1}$	$08^{0}38.050^{1}$	4.9m
ZONE 2S1	419.01m	$007^{0}13.926^{1}$	$08^{0}37.289^{1}$	4.0m
ZONE 2S2	339.41m	$007^{0}13.934^{1}$	$08^{0}39.281^{1}$	4.6m
ZONE 2S3	341.87m	$007^{0}13.966^{1}$	$08^{0}41.170^{1}$	4.4m
ZONE 2S4	411.01m	$007^{0}23.036^{1}$	$08^{0}18.084^{1}$	3.9m
ZONE 3S1	309.91m	$007^{0}38.676^{1}$	$08^{0}38.009^{1}$	6.1m
ZONE 3S2	409.91m	$007^{0}41.936^{1}$	$08^{0}30.125^{1}$	3.6m
ZONE 3S3	319.07m	$007^{0}54.926^{1}$	$08^{0}21.288^{1}$	5.6m
ZONE 3S4	359.21m	$007^{0}83.945^{1}$	$08^{0}71.283^{1}$	4.6m
ZONE 4S1	307.90m	$007^{0}43.931^{1}$	$08^{0}42.284^{1}$	3.8m
ZONE 4S2	319.01m	$007^{0}49.438^{1}$	$08^{0}42.204^{1}$	3.5m
ZONE 4S3	387.65m	$007^{0}55.996^{1}$	$08^{0}52.009^{1}$	3.1m
ZONE 4S4	398.54m	$007^{0}57.731^{1}$	$08^{0}51.906^{1}$	5.5m

ZONE 5 S1	455.01m	$007^{0}13.400^{1}$	$08^{0}22.274^{1}$	4.4m
ZONE 5S2	421.28m	$007^{0}43.006^{1}$	$08^{0}48.277^{1}$	5.1m
ZONE 5S3	333.21m	$007^{0}23.239^{1}$	$08^{0}60.271^{1}$	3.6m
ZONE 5S4	421.07m	$007^{0}31.970^{1}$	$08^{0}44.244^{1}$	4.0m

3.0. LABORATORY EXPERIMENTAL PROCEDURE

Laboratory test such as Absorption Test, Abrasion Test, Density, Compressive strength and Impact Test were performed in compliance with NIS: 585, (2007) Specification

ABSORPTION TEST

An absorption test was carried out on the concrete, some portion of the samples were immersed in water to ascertain its rate of tolerance to water, this is essential to envisage the concrete behavior less moist condition. To guide against flood attacks in areas where such sandcrete blocks are used. At the topmost period of the rainy season, the surface flow may rise to flood the structures. The ability of such construction to withstand the flood will be established by the absorption rate of the constituents with which it is constructed. Absorption test is essential on sandcrete blocks to guide against ground table incident which could rise particularly in the rainy season or if there is water dislodgment from a reservoir in the area. Any structure erected in such environment will be subjected to the threat of instability. More reason why absorption test of the concrete is really required.

A laboratory test was conducted, on the sample using equation 1 below

$$\text{Water Absorption (\%)} = \frac{Mw2-Mw1}{Mw1} * 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where:

M_w1 = Weight of the block before subjecting to water and

M_w2 = Weight of the block after subjecting to water

COMPRESSIVE STRENGTH (CS):

This test was performed to investigate the performance of the blocks after the normal curing age to establish the characteristic strength at the curing age. This is the extreme load per total area of the material. This was done using CONTROL CR2-030 Hydraulic compression machine. Failure load divided by the area in (N/mm^2)

$$\text{COMPRESSIVE STRENGTH (CS)} = \frac{MFL}{CA} * 1000 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where MFL is the max failure weight and CA is the Average of the surface of the block

ABRASION TEST:

The test was performed to check the effect of block surface to wearing, two separately weighed samples of the sandcrete blocks was brushed using the icon file. The same effort and number of motion were used on each sample, then the final weight of each sample was taken.

$$AB = \frac{Ws1 - Ws2}{Ws2} * 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Where W_{S1} is the Initial weight and W_{S2}= weight of the sample after brushing

IMPACT TEST:

The test was conducted to measure the shattering effect of the block when falling from a height during construction activities. The initial weight of the sandcrete block sample was taken and then subjected to drop at a height of 2m. After the fall, the final weight of the specimen was recorded. The test was repeated two times

$$\text{Impact Test} = \frac{w1 - w2}{w2} * 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

Where w1 is the Initial weight the fall and W2= weight of the sample after falling from a height.

4.0 RESULTS & DISCUSSION

COMPRESSIVE STRENGTH TEST

The outcome of the compressive from the sand create hollow block varied between 1.03 and 0.63 N/mm2 , 0.60 and 0.30 N/mm2 , 0.50 and 0.28 N/mm2 , 1.16 and 0.73 N/mm2 , 1.63 and 1.45 N/mm2 for zone 1-5 and sample 1-4 respectively which is illustrated in table 1 . Analysis illustrated above shows that block in zone 1-4 did not comply with the general specification of the NIS. Since the compressive strength of their sandcrete hollow block was not within the specified limit. It is Noteworthy, that is, only the block producers in zone 5 are found within a specified limit of 1.5N/mm minimum for non-load-bearing walls.

WATER ABSORPTION TEST:

The absorption test results varied between 13.2% and 15.4%, and 13 and 16.5, 14% and 15.8%, 13.6 and 16.4, 09 and 13.5 for zone 1-5 and sample 1-4, respectively as shown in table 1. The analysis showed that as the strength increases the absorption values also decrease and vice versa and that it is only Block industries in zone 5 that showed compliances with the specification of 12% maximum for sandcrete hollow block water absorption test.

BULK DENSITY TEST

The result of the bulk density varied between 1200 kg/m³ and 1045 kg/m³, 1073 and 1010kg/m³ , 1035 and 1005, 1138 kg/m³ and 1045, 1865 kg/m³ and 1788 kg/m³ for zone 1-5 and sample 1-4 respectively as shown in table 1 the analysis showed that the sand create hollow block produced in zone 1-4 are not within the limit set by NIS for block density of 1800kg/m³ except zone 5 sample 1-3 only . The implication of lesser density below the minimum specified will result in the weak block which results in the collapse of building in the future.

ABRASION TEST

The results varied between 40 and 65 %, 40 and 75 %, 48 and 95 %, 40 and 88 %, 30 and 46 % for zone 1-5 and sample 1-4 respectively as shown in table 1. The analysis showed that the higher density and strength cause a reduction in the abrasion thereby reducing the effect of wearing on the material

IMPACT TEST

The impact test varied between 50 and 85 %, 45 and 94 %, 55 and 96 %, 47 and 93 %, 35 and 46 for zone 1-5 and sample 14 respectively as showed in table 1. The results showed that zone 1- 4 showed a higher shattering effect while zone 5 sample show a lesser percentage of shattering, the implication of this is that higher impact values show a poor block quality while lesser impact value shows a sound block quality for construction purpose.

Table 3: Result of Mechanical Properties of Sandcrete Hollow Block Produced in Ado Ekiti, Ekiti State Nigeria for Zones 1-5 samples

	Summary Result of Mechanical Properties of Sandcrete Hollow Block Produced in Ado Ekiti, Ekiti State Nigeria for Zones 1-5 samples			
Mixes for LOC.1-4	1:15	1:18	1:20	1:22
Compressive Strength (N/mm^2	1.03	0.91	0.73	0.63
Bulk density (Kg/m^3	1200	1146	1138	1045
Absorption (%)	13.2	13.6	14.5	15.4

Impact test (%)	50	65	78	85
Abrasion test (%)	40	48	55	65
ZONE 2 / Mixes for LOC.1-4	1.14	1.17	1.20	1.23
Compressive Strength (N/mm^2	0.60	0.44	0.39	0.30
Bulk density (Kg/m^3	1073	1020	1037	1010
Absorption (%)	13.0	15.2	15.6	16.5
Impact test (%)	45	73	85	94
Abrasion test (%)	40	45	60	75
ZONE 3 / Mixes for LOC.1-4	1.16	1.18	1.21	1.24
Compressive Strength (N/mm^2	0.50	0.46	0.40	0.28
Bulk density (Kg/m^3	1035	1025	1015	1005
Absorption (%)	14.0	14.5	15.3	15.8

Impact test (%)	55	69	83	96
Abrasion test (%)	48	56	65	95
ZONE 4/ Mixes for LOC.1-4	1.13	1.16	1.20	1.22
Compressive Strength (N/mm^2	1.16	1.03	0.84	0.73
Bulk density (Kg/m^3	1138	1093	1079	1045
Absorption (%)	13.6	14.5	15.4	16.4
Impact test (%)	47	58	85	93
Abrasion test (%)	40	45	75	88
ZONE 5/ Mixes for LOC.1-4	1.09	1.10	1.11	1.12
Compressive Strength (N/mm^2	1.63	1.55	1.50	1.45
Bulk density (Kg/m^3	1865	1815	1805	1788
Absorption (%)	09	11.5	12.3	13.5
Impact test (%	35.3	40.2	43.3	45
Abrasion test (%)	30.3	35.4	40.5	45

5.0 CONCLUSIONS

From the laboratory analysis conducted on the samples, we realized only blocks producers within zone 5 were found within the specified limit of 1.5N/mm minimum for non-load bearing walls. Also, it is the still same zone 5 block producers that complied with the stipulated specification of 12% maximum for sandcrete hollow block water absorption test.
The analysis showed that the sandcrete hollow block produced in zone 1-4 are not within the stipulated measure set by NIS for block density of 1800kg/m³ except zone 5 sample 1-3 only, analysis showed that the higher the density and the strength, causes a reduction in the abrasion thereby reducing the effect of wearing on the material. It was dudeced from the test as well that Zone 1- 4 showed a higher shattering effect while zone 5 sample shows a lesser percentage of shattering, the implication of this is that, higher impact values shows a poor block quality while lesser impact value shows a sound block quality for construction purpose.

6.0 REFERENCES

ABDULLAHI, M., 2005. The compressive strength of sandcrete blocks in Bosso and Shiroro areas of Minna, Nigeria. *AU JT*, **9**(2), pp. 126-131.

AJAGBE, W., GANIYU, A., and ADENIJI, A., 2013. Quality assessment of Sandcrete blocks in Ibadan; A review. *Epistemics in Science Engineering and Technology*, **3**, pp. 272-277.

ANOSIKE, M. and OYEBADE, A., 2012a. Sandcrete blocks and quality management in Nigeria Building Industry. *Journal of Engineering, Project, and Production Management*, **2**(1), pp. 37.

ANOSIKE, M. and OYEBADE, A., 2012b. Sandcrete blocks and quality management in Nigeria Building Industry. *Journal of Engineering, Project, and Production Management*, **2**(1), pp. 37.

BAIDEN, B.K., and TUULI, M.M., 2004. Impact of quality control practices in sandcrete blocks production. *Journal of Architectural Engineering*, **10**(2), pp. 53-60.
ODEYEMI, A., DADA, A., OGUNBANJO, O., and OJO, M., 2010. Bacteriological, physicochemical and mineral studies on Adele spring water and soil samples in Ado Ekiti, Nigeria. *African Journal of Environmental Science and Technology*, **4**(6),.

ODEYEMI, S., 2012. Effect of types of sandcrete blocks on the internal microclimate of a building. *Journal of Research Information in Civil Engineering (RICE), Department of Civil Engineering, University of Ilorin, Ilorin, Nigeria*, **9**, pp. 96107.

ODEYEMI, S., ANIFOWOSE, M., OYELEKE, M., ADEYEMI, A. and BAKARE, S., 2015. Effect of Calcium Chloride on the Compressive Strength of Concrete Produced by Three Brands of Nigerian Cement.

OKAFOR, F. and EGBE, E., 2017. Models for predicting compressive strength and water absorption of laterite-quarry dust cement block using mixture experiment. *Nigerian Journal of Technology*, **36**(2), pp. 366-372.

OMOREGIE, A., 2012. Impact of vibration time on the compressive strength of hardened sandcrete building blocks. *Buildings*, **2**(2), pp. 153-172.

SAMSON, D., ELINWA, A. and EJEH, S., 2002. Quality assessment of hollow sandcrete blocks. *Nigeria Journal of Engineering Research and Development*, **1**(3), pp. 37.

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