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Full Length Research Paper

Assessment of Quality of Concrete Production in Selected Construction Projects within Federal Polytechnic Kaura Namoda Zamfara State

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ABSTRACT: The use of subpar building materials, which consistently results in structural failure and the loss of life and property in Nigeria's construction industry, is one of the main issues encountered during the construction of buildings. This is a review of the concrete production at a few Federal Polytechnic Kaura Namoda construction sites. It was accomplished by rigorous examination of contract documentation, with special attention paid to mix design/specification. The information acquired from the document was then used to create concrete samples (control sample). Renal samples of actual concrete were collected at random, cured (sample specimen), and tested for compressive strength after 7, 14, 21, and 28 curing days. A checklist on the proper procedure of concrete manufacture was created and used to analyze how concretes were produced. The study found that non-adherence to the necessary processes of concrete manufacturing, such as using the incorrect water/cement ratio and using a crude way of batching, were the most common difficulties in concrete production. It was also found that the average strength of concrete produced on two construction projects were 10.47 N/mm^{2}and 6.96 N/mm^2 which did not attain the minimum strength required at 28 days 21 N/mm^2 by the BS 1881, (1983b) part 116, while the concrete produced on another sites has a strength of 20.01N/mm^2 at 28 days which is close to the specification of BS 1881 and the controlled sample average strength of concrete at 28 days was 23.79N/mm^2 which is within the range specified by the BS 1881 part 116 (1983b). Based on the results, the compressive strength of the concrete collected from sites was 14 percent lower than the control specimen, so it was recommended that 14 percent be added to the estimated design strength as a factor of safety to account for problems with the handling of the concrete materials and other construction inaccuracies. The government and professional organizations should work together to enforce the National Building Code.

Keywords: Concrete, compressive strengths, evaluation, production, quality

INTRODUCTION

One of the serious problems facing the construction industry in Nigeria is structural failure. Adenuga (2008) in Olufemi (2015) reported that over 136 reported cases of collapsed building occurred between 1974 and 2008. Result of investigation revealed that the use of defective construction materials as one of the major cause of structural failure (Emeka, 2011). Concrete is the most widely used construction material, not only Nigeria, but all over the world. According to WBCSD (2000) twice as much concrete is used in construction around the world than other construction materials-including wood, steel, plastic and aluminum. Thus, any discussion on structural failure would not be complete without reference to concrete. (Dahiru, 2010). However, unlike most other prominent construction material like steel, which is produced under carefully controlled conditions, with even the properties

determined in a laboratory, and clearly described in a manufacturer's certificate, the quality of concrete is subject to variation from the one designed or specified. Concrete's constituents are handled and subsequently mixed together to give certain required quality/properties; these include compressive strength, workability, durability and good cohesion. It is certain that when these requirements are not met, failure may occur (Okereke, 2007). To guide against failure, there is the need for quality control; which according to Gambhir (2006) is a corporate, dynamic programme to ensure that all aspects of materials, equipment and workmanship are well looked after. Quality control is, therefore, conformity to the specifications. The owner will have no right to expect anything more than what is in the specification. The builder, on the other hand knows that anything less than what is in the specification will not be acceptable to the client. International Atomic Energy agency. IAEA (2002) defined quality control as the controls applied to each production stage to produce a qualitative product.

According to Gambhir (2006) the most practical method of quality control is to conform to specifications. One major and very important step in a quality control is testing of concrete. For the fact that compressive strength is the most important property of concrete, which is used to assess most other properties of concrete, compressive strength is used as a quality index by not only design and control engineers, but also professional builders (McIntosh, 1997; Gupta and Gupta, 2006; Shetty, 2009 and Neville and Brooks, 2010). Most of the concrete used in the construction industry in Nigeria is in-situ cast concrete. Besides that, there is clear evidence that handling of constituent materials and of the finished product before placing may be responsible for the production of substandard concrete. This brings the need to improve the handling standard of concrete and its constituent materials. In addition, it is not only desirable but necessary that design and control engineers should know the quality of concrete actually produced on site so that it can give them a good idea of the extent of deviation from the ones specified in the contract document. This will assist in arriving at the reasonable estimate of allowance (Factor of safety) that should be provided in design and specification of concrete, so as to guide against failure. This explains the reason why efforts were made by many researchers relating to problem of concrete production in Nigeria such as: Garba *et al.* (2004), Okereke (2007), Dahiru (2010), Emeka (2011) and Sadiku (2011). According to Okereke (2007) there are contradictions in the results of many of the researches undertaken on concreting, largely because researchers were unable to simulate site conditions in the laboratory. This has led some experts in hot weather concreting in concluding that the result of study on concrete production, as far from being conclusive (Okereke, 2007). This brings the need to formulate yet another loom to the study of concrete production. This is particularly important in view of the dynamic nature of the construction industry. Past results may no longer be suitable currently. Added to the fact that the ingredients for good and bad concrete may be the same, the difference in quality lies with the acquaintance dexterity and experience of the person producing the concrete. This is a report on the evaluation of the concrete production in selected construction Projects within Federal Polytechnic Kaura Namoda typical Zamfara State. In order to achieve the desired goal, the following steps were followed:

Study the handling process and the workers producing concrete.

To determine the quality of concrete as specified by contract document with special reference to structural design, specification and Bills of quantities.

To Study contract documents, the handling process and caliber of workers especially level of supervision and the commitment exhibited by the workers towards the achievement of good quality concrete during concrete production.

To use the information so obtained, from step 1, 2, and 3 to produce control samples of concrete and determine the quality of concrete produced on site.

To compare the quality of concrete in selected construction projects within federal polytechnic Kaura Namoda. and the one produced in laboratory.

METHODOLOGY

The methods used can be summarized under the following headings:

Field survey and study of contract documents

(a) Studying the contract documents to come up with the actual quality of Concrete specified.
(b) Site visit to observe the concrete practices. – Especially handling process
(c) Structured interview and interaction with the supervisors of concrete production.

Experimental program

In view of the fact that researchers have undertaken studies on various aspects of concrete production in Nigeria, this paper made an attempt to report on, not only the quality of concrete produced but to examine effort made in solving the observed problems of concrete production. For instance, problems due to high temperature and high relative humidity, etc. To achieve the desired objective, three construction sites were selected

for that purpose. These construction sites are located within the Federal Polytechnic Kaura Namoda, were included in the study. Contract documents for such projects were studied. So as to know the quality of concrete specified in the contract document, for projects under study. This was then used to produce a control sample. Also, the actual concrete produced in these sites under study, were randomly collected and their compressive strengths were determined and compared with the standard. The study was confined to medium and Large sized projects; for the fact that recent study revealed that structural failure is more pronounced in buildings from five storey down wards (Ede, 2010 and Dauda, 2011).

MATERIALS

The materials used for the study are: cement, fine aggregate coarse aggregate and ready mixed concrete from the selected construction sites within Federal Polytechnic Kaura Namoda

Cement

The cement used for the experiment was Ordinary Portland Cement, OPC, manufactured and recently supplied by Sokoto cement. It conforms to the relevant Nigerian and British standards.

Fine aggregates

Fine aggregates used in this research work were clean and air - dried river sand obtained from Zamfara state. It was sieved with a 5mm B5 112 (1971) sieve, so as to remove the impurities and larger aggregates. Before the fine aggregate was used; it was subjected to sieve analysis. This was undertaken in accordance to the BS 933 Part 1 (1997).

Coarse aggregates

The coarse aggregate used were crushed granite stones from single quarry obtained from Zamfara State, Nigeria.

Harmful impurities

The aggregates were inspected in order to determine whether they contain harmful impurities in such a form or quantity that can adversely affect the properties of concrete. The result of the inspection showed that no such impurities were present.

Test samples

Ready mixed concrete was collected from the actual concrete sample produced and used for the construction of buildings at the sites under study. The samples were prepared in 150mm x 150mm x 150mm cubes, cured and subjected to compressive strength test after each curing day. Then a control sample was produced using the specification contained in the Contract documents. This is in order to compare the samples produced at each site with one specified in the contract document. A total of 12 concrete cubes (150mm x 150mm x150mm) were produced and used as control sample for this experiment. While 36 concrete cubes were obtained from the sites considered this was because in all the sites considered the specifications were the same.

Study of the concrete production

Documents

These consist of Bills of Quantities, Specifications article of agreements and conditions of contract which were under the custody of the contractor and were carefully studied and used for this study.

Caliber of operatives producing the concrete

An interaction with the operatives assigned to produce concrete was carried out. So as to know the quality of manpower used for concrete production in these sites.

Method and quality of supervision of concrete production

Part of the research entails close study of concrete production on the selected sites. This was undertaken by, personally, visiting the sites and making a close observation of the nature, quality of materials, method of batching, mixing and time of mixing concrete, etc. The way and manner in which the aforementioned activities were carried out, were noted and then compared with a prepared checklist on the right procedure of undertaking these activities, as enunciated by experts. The quality and extent of supervision was also investigated.

Method of assessing concrete production

Among the important factors that should be considered in the production of qualitative concrete, thirty (30) of them were used as checklist and points were allocated to each factor, depending on the extent of conformity to the set standard. The grading is as follows: *Excellent – 5, Very*

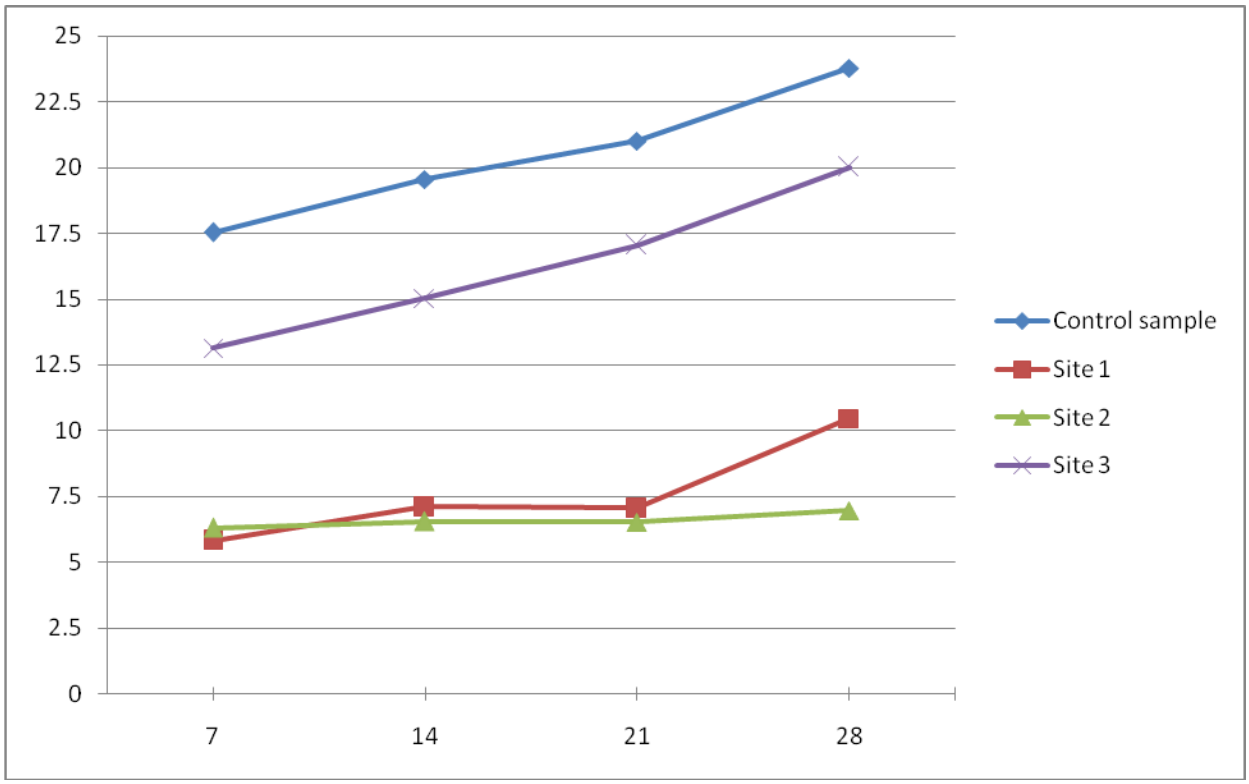

Figure 1: Compressive strength of concrete samples from the three sites**.**

Good – 4, Good – 3, Fair – 2, Poor – 1, if such factor was not considered – .0. For the overall assessment, the following were used to grade concrete production in the sites examined *150 – 129 – Excellent, 120 - 91 – Very Good, 90 – 61 Good, 60 – 31 – Fair, 30 – 0 Poor.* Personal judgment, careful observation and answers from the supervisors were used in evaluating concrete production in the sites studied.

Test procedures

The test of concrete was carried out in the Department of Civil Engineering Technology Laboratory, Federal Polytechnic Kaura Namoda Zamfara State in accordance to the relevant standards, especially the British Standards. For the fact that the most important property of concrete at fresh and hardened stage are workability and compressive strength, respectively. The following tests were undertaken.

Assessment of workability

Slump test was used to assess the workability of the fresh concrete sample used for the experiment.

Compressive strength test

The compressive strength of concrete sample from the chosen construction sites were determined.

Cube density test

Density of concrete samples were determined.

RESULTS

Results obtained from the experiment are presented under the following headings:

Compressive strength

The results of the average compressive strength test for the controlled sample and the samples obtained from the sites considered are given in (Figure 1). It can be observed from the figure that the controlled sample has strength ranging from 17.54N/mm^2 to 23.79N/mm^2, which satisfy the minimum strength of concrete required for structural purposes as specified by BS 1881 part 5 (1975). While the compressive strength of concrete sample for site 1,2,3 and site 4,5,6. at the 28days of curing have not satisfy the minimum requirement as specified by BS 1818 1975. The graph has clearly depicted the wide difference that exist between the samples produced at the sites and the control cubes. This was due to non-adherence to the correct

Table 1: Average density.

S/N	Age(days)	Control	Site 1,2.	Densities Site 3,4.	Site 5,6.
1	7	2360.37	2277.50	2392.10	2994.56
2	14	2362.47	2299.20	2197.53	237926
3	21	2368.40	2824.70	2281.48	2293.33
4	28	2380.25	2354.50	2373.33	2320.00

Table 2: Slump test.

Concrete mix	w/c ratio	Slump (mm)	Degree of workability
Controlled	0.62	20	Low
Site 1&2		100	High
Site 3 &4		0	Extremely High
Site 4 &6		150	High

Table 3: Average strength, standard deviation and coefficient of variation for the experiment.

Age		Control	Site 1,2	Site 3,4	Site 5,6
28days	Mean Strength (N/mm^2)	23.79	10.47	6.96	20.01
28days	Standard Deviation (N/mm^2)	1.32	0.46	0.57	0.61
28days	Coefficient of variation (%)	5.55	4.39	8.19	3.05

procedures of concrete production as observed during the study.

Average density

Table 1 shows the results of the average Density of controlled concrete and those ones produced by three sites considered. The densities were determined at saturated surface dry (S.S.D) condition. The density ranges from 2360.37kg/m^3 to 2380.25kg/m^3 for the controlled concrete produced. This compares well with the normal weight concrete which is the range of 2355kg/m^3 to 2560kg/m^3. While the density for the three sites ranges from 2197.53kg/m^3 to 2994.56kg/m^3.

Workability

The workability (slump) test for the controlled concrete and those obtained from the three sites considered are shown in (Table 2). From (Table 2), the controlled concrete sample has a slum of 20mm, while sites considered have workability ranging from 100mm to 150mm slump which is relatively higher than that of control sample. This is to be expected because result of study of concrete production in these sites shows that too much water was added to the mix in order to achieve workability. This results in the reduction of the compressive strength. Result of investigation shows that in almost all the batching process, the amount of sand, is greater than coarse aggregate

DISCUSSION

Compressive strength

Looking at the results of the compressive strength test, it can be observed from (Table 4) that the compressive strength in site 2 is less than that of the controlled one. This represent 14% of compressive strength which is far below the provision of BS 1881(1983) Part 116. This may be due to the fact that the workability is extremely high and non-adherence to the correct procedure of concrete production.

Density

The results of test on density, in (Table 1) show that the density of controlled concrete sample is relatively higher than the concrete sample from the three sites. This may

Table 4: Measure of materials used in the production of concrete.

S/No.	Materials	Quantity
1.	Cement	1 Bag
2.	Sand	8 – 10 head pans
3.	Coarse aggregate	8 - 10 head pans
4.	/Chippings	10 head pans
5.	Water	11/2 – 21/2 buckets

Appendix A1: Time limit for concrete mixing.

Capacity (m^3)	Time of mixing (minutes)
2 or less	1 ½
2.5	2
3.0	2 ½
5.0	3

Source: Murdock and Brook (2002) in Emeka, (2011 p.28)

be due to insufficient consolidation of concrete sample during production which can affect the quality of concrete produced.

Contract documents

Result of the study of the contract documents shows that there was a comprehensive specification on the expected quality of the concrete to be used by the contractors, for each of the projects studied. However, the specification was exactly the same for all the three sites. Thus there was no consideration given to the peculiar nature of these sites. Also the use of plasticizers was specified in the contract document.

Check list

As it was observed earlier, concrete production in each of the sites was assessed using a checklist. Result showed that all the sites considered could not get a pass mark (50%) as they were not strictly observing those steps. Important steps such as ordering from same source, non-adherence to the specifications, provision of good storage facilities, testing of materials, competent labour force, regular curing, consolidation, etc were not observed (See appendix).

Observation of concrete production

Result of investigation shows that contrary to what was stated in the contract documents, of the whole projects understudy, (that different grades of concrete should be used, for various structural elements), none of the sites examined, design and produce concrete in accordance to specification. Instead a rather crude/primitive method was used. For example, in most sites, details of one of the popular way and manner of batching of the ingredients were carried out is presented in (Table 4).

Mixing

All the construction sites visited made use of concrete mixer for the production of concrete. Close observation shows that the constituents were put in mixer in the following order:

Water 2. Coarse aggregates (half of the required amount) 3. Cement 4. Sand 5. Coarse aggregates (remaining half of the required amount). Also, an assessment of the time of mixing was carried out using a standard/table (Appendix A1) which gives the right time of producing specific volume of concrete. Result of close study shows that this is yet another aspect of concreting that was carried out in accordance to the correct procedure as the of mixing in all the sites observed was over and above the time in the (Appendix A1). However, one good thing was the correct positioning of the mixer close to the point of use. The only problem was the use of outdated method of transportation in all the sites – using head pans and wheel barrows.

Water-cement ratio

Using the result of investigation as shown in (Table 4), attempt was made to estimate the water-cement W/C ratio. This was achieved by weighing both the water and cement; it was, then used to calculate the water – cement ratio. Result shows that water/cement ratio used by these sites ranges from 0.84 – 1.05. Close observation shows that sometimes it could, even, be more than that. When this is compared with the range of values (0.4 - 0.9) given by experts e.g Lyons (1997), it can be observed that the amount of water used, for concrete production, in all the

sites studied was over and above the required amount. This, no doubt, has negative influence on the compressive strength of concrete, hence the quality of concrete produced. The reason always given by the workers on why they made use of high w/c ratio was to enhance workability even though it reduces the compressive strength of concrete. The best solution should have been to reduce the water and use plasticizers. However, none of the sites used the plasticizers or any admixture. Okekere (2007) noted that one of problem facing concrete production in Nigeria, is the weather condition especially in the area these sites were located.

Conclusion

Based on the test result, analysis and discussion carried out the following conclusions were drawn.

The crucial procedures involved in producing concrete on building sites did not receive adequate attention. The lack of adherence to specifications may be the cause of the problem with concrete manufacturing on the study sites.
Batching was done "by eye," no tests were performed on the concrete produced at these locations, unqualified labor was used, and so on. There was little thought given to the unique nature of each project or building location. In many circumstances, structural elements are not given any consideration when selecting aggregate sizes and, in certain cases, even the grade of concrete to be utilized. The concrete produced was not designed, and all batching was done by volume. There was too much water used, and the sand is almost always higher than the coarse aggregate.

There was no specialist in concrete production overseeing the production of concrete on the sites investigated. As a result, concrete, as a structural and crucial material, has not received the attention it needs. The density of the concrete produced at the sites under consideration ranges from 2124.8kg/m^3 to 2423.70 kg/m^3. These values are lower than the standard weight concrete values, which range from 2355kg/m^3 to 2565kg/m^3.
The compressive strengths of the concrete produced on the sites considered compare unfavorably with that of the control samples at the same age, for example, site l,2,3, and 4 have an average compressive strength of 10.47N/mm^2 and 6.96N/mm^2 while site 5 &6 has 20.01N/mm^2 these values are 13.32N/mm^2 and 16.83N/mm^2 for sites less than that of the control samples of 23.79N/mm^2 while site others has 3.78 Based on a survey of typical construction sites, it may be determined that the sites use crude/unorthodox methods of producing concrete.

Recommendations

1. In view of the fact that the compressive strength of concrete produced in all the three sites are below standard, by 14%, designers should always give a reasonable factor of safety of at least 14%, in their design of concrete. They should consider the peculiar nature of both the project and the construction sites.
2. The client and contractors should employ registered professionals who can handle the production of concrete so that the safety of the occupants will be ensured.
3. Strict adherence to the specifications and carrying out of tests on concrete produced should be emphasized. In this regard, the professional bodies and government agencies should put eyes on what is happening in Nigeria construction project most especially on production of concrete. In this regard, the National Building Code should be enforced.
4. Further tests should be carried out on these sites to ascertain the quality of concrete so produced and its significant consequences on the users of such project

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