Nigerian Journal of Technology (NIJOTECH)
Vol. 37, No. 3, July 2018, pp. **562 – 569**

Print ISSN: 0331-8443, Electronic ISSN: 2467-8821
www.nijotech.com
http://dx.doi.org/10.4314/njt.v37i3.1

ABANDONED PROJECTS-IMPLICATION ON THE STRENGTH OF EXPOSED STEEL AND CONCRETE IN THE SOUTHERN REGION OF NIGERIA

F. O. Okafor[1], N. N. Osadebe[2] and I. J. Sylvester[3,*]
[1, 2, 3,] DEPARTMENT OF CIVIL ENGINEERING, UNIVERSITY OF NIGERIA, NSUKKA, ENUGU STATE, NIGERIA
Email addresses: [1] *fidelis.okafor@unn.edu.ng*, [2] *mkemamaka@yahoo.co.uk*, [3] *johnsylvester@elalan.com*

ABSTRACT
This research is centered on the investigation of the implication of abandonment on the strength of exposed steel and concrete in an abandoned project; as most abandoned project are continued without due consideration to the current strength of the structural members, which may lead to eventual collapse, if the structural members have failed in strength. Six abandoned project sites were investigated: three in Port Harcourt, Rivers state and the other three in Lagos, Lagos state, Nigeria. Thus limiting the investigation to Southern region of Nigeria where the temperature ranges between 23°C and 32°C and precipitation/rainfall ranged between 36mm and 410mm.The Periods of the abandonment ranges from three to thirty-five years. All structural members were cast in-situ. Visual inspections were carried out on site, rebound hammer test was done, concrete samples were cored and steel reinforcement bars were cut from site. Laboratory test and analysis were carried on te cored samples as well as tensile test carried out on the steel samples. Data obtained from both field and laboratory analysis, were analyzed using Excel regression analysis and a model was obtained to help determine the estimated steel strength of exposed steel reinforcement bars after a period of abandonment in the region considered.

Keywords: *abandonment, concrete, steel, compressive strength, tensile strength*

1. INTRODUCTION
Project abandonment is the refusal or failure, to complete a contract before a practical completion date. Abandoned buildings, stadia, churches, roads etc., are seen scattered all across the nation, with the hope that they will be continued in later times. Some have been successfully completed, while others were completed to the detriment of the occupants. It is a known fact that nonfunctional Government policies, defective procurement procedures, incompetent contractors, defective design and so on, contributed significantly to project abandonment. This investigation will determine the effect of weather on exposed steel reinforcement and concrete of abandoned projects in the Southern region of Nigeria, Perform an in-situ non-destructive test on the concrete structural members, carry out visual inspections on site to identify visible defects on structural members, Perform laboratory test on samples of steel reinforcement bars cut from the site, obtain data from laboratories involved in Non-destructive test, to perform statistical analysis and to present a model, for the rate of deterioration of exposed steel reinforcement bars.

2. LITERATURE REVIEW
Abandoned projects such as houses, churches, schools, roads, bridges, dams, tunnels, airport, sea port etc., are littered across Nigeria. According to a report in [1] Nigeria has become the "world's junk-yard of abandoned projects, which worth billions of naira and that it is greatly unthinkable that Nigeria who is blessed with so great potentials in the building and construction industry could experience such magnitude of project abandonment. According to another report by [2] there are about 4000 uncompleted or abandoned project belonging to the Federal Government of Nigeria with an estimated cost of above N 300 billion. These projects will take at least 30 years to complete at the present execution capacity of government. He also stated that issue of abandonment has been left without adequate attention for too long, which is now having a multiplier effect on the construction industry in particular and the national economy as a whole. According to [3], inadequate project planning, inadequate fund, inflation, bankruptcy of Contractor, Variation of project scope, political factor, death of

*** Corresponding author tel: +234 – 815 – 979 – 1472**

client, incompetent project manager, wrong estimate, inadequate cost control, faulty design and delayed payment are responsible for project abandonment. More still [4] identified unqualified Contractors, kick-starting a lot of Task at the same time, unspecified Scope of Work and poor Budget Planning as the causes of project abandonment. Furthermore, [5], in their opinion, revealed that nonfunctional Government policies, defective procurement procedures and incompetent contractors are responsible for the various levels of project abandonment.

According to [6], the causes of project abandonment include contractor's improper planning, contractor's poor site management, inadequate contractor experience,, inability of clients to pay for completed works, problems with subcontractors, shortage of materials and labour, equipment failure and availability, lack of communication between parties and mistakes during construction works

2.1 Effects of Project Abandonment

Abandonment of projects, indeed have some negative effects to the general public and the environment at large. In the view of [7], abandoned projects are seen as a conduit pipe through which Nigerian resources are being wasted away without benefiting the people.

Also, [8] identified wastage of public fund and national resources as the effect of abandonment. At the emergence of a new government in power, projects commenced by previous government are abandoned and new ones which may not be completed are commenced. This results in a cycle of abandoned projects everywhere.

According to [3], the effect of abandonment include disappointment of the populace/users, low living standard, wastage of resources, reduction in employment opportunities, decrease in tempo of construction activities, decrease in revenue accruing to government and difficulty in attracting foreign loans. More still, [9] identified physical, mental, social, and economic health and wellbeing of individuals, family and communities as being adversely affected as a result of project abandonment. Moreover [2], identified time and cost overrun, disputes, arbitration, litigation and total abandonment as the effect of project abandonment.

2.2 Recommendations to Solve Construction Project Abandonment

According to [5], the following are the recommendations to solve construction project abandonment.

1. Only new projects, which can be completed with the available resources, should be initiated.
2. The selection processes and consultant should be characterized by accountability, transparency, honesty and integrity.
3. The use of political undertone rather than economic advantage in sitting of projects should be discouraged.
4. Corruption at the level of Government and other stakeholders in the housing sector should be curbed through Due process, Economic and Financial Crime Control (EFCC), Budget Monitoring and Price Intelligence Unit (BMPIU) and other Crime Control Agencies.
5. The need to set up a National Construction Industrial Bank is overdue.

In the view of [10], relevant laws have to be strictly adhered to to check the abnormality of abandoned projects.. Section 63 (1) of the Public Procurement Act which states thus: 'In addition to any other regulations as may be prescribed by the Bureau, a mobilization fee of no more than 15% for local suppliers and contractors and 10% for foreign suppliers and contractors may be paid to a supplier or contractor …' must be firmly applied. According to the PPAC, it is not uncommon for contractors to be paid mobilization fees in excess of 50% of the contract sum, often in apparent violation of the law. The federal government needs to, as a matter of urgency, comply with the provisions of the Public Procurement Act. The government must curb the temptations or pressures to embark on new projects when so many remain uncompleted or abandoned. Desirable projects must be continued irrespective of whichever administration initiated them.

In the views of [11], cost Engineering and Engineering economy should be practiced in order to reduce the problem of project abandonment.

3. METHOD

The field work comprises of visual inspection of the various structural members, the use of rebound hammer to determine the estimated compressive strength of concrete members, the use of coring machine to obtain core samples for laboratory test and cutting samples of reinforcement bars tor tensile steel test.

3.1.1. Visual Inspection

The first most manifested characteristic as witnessed on the visited sites was a seemingly dilapidated scene of concrete elements obscured by matrix of projected reinforcements, rotten fragments of timber and thick shrubs. Close inspection however revealed the growth of algae and moss on concrete surfaces. Surfaces associated with any of these organisms are liable to constant dampness.

Rusting of exposed steel bars was witnessed on the site. There were no visible deformations of concrete structural members in the building. The sizes of the various structural members were uniformly maintained all through the structure. This could have been achieved as a result of good formwork and proper bracing of formwork.

There were neither honeycombs nor exposed reinforcement bars, which was as a result of good vibration and proper placement of biscuits to ensure adequate cover for the reinforcement bars.

Also observed on the slab, were thin layers of concrete, which could be easily peeled off to expose harder concrete layer underneath. This could be as a result of concrete bleeding during casting.

3.2 The rebound Hammer Test

A Schmidt hammer, also known as a Swiss hammer or a rebound hammer, is a device to measure the elastic properties or strength of concrete or rock, mainly surface hardness and penetration resistance. It was invented by Ernst Schmidt, a Swiss engineer. The hammer measures the rebound of a spring-loaded mass impacting against the surface of the sample. The test hammer will hit the concrete at a defined energy. Its rebound is dependent on the hardness of the concrete and is measured by the test equipment. By reference to the conversion chart, the rebound value can be used to determine the compressive strength. When conducting the test the hammer should be held at right angles to the surface which in turn should be flat and smooth. The rebound reading will be affected by the orientation of the hammer. When used in a vertical position (on the underside of a suspended slab for example) gravity will increase the rebound distance of the mass and vice versa for a test conducted on a floor slab. The Schmidt hammer is an arbitrary scale ranging from 10 to 100. Schmidt hammers are available from their original manufacturers in several different energy ranges. These include: (i) Type L-0.735 Nm impact energy, (ii) Type N-2.207 Nm impact energy; and (iii) Type M-29.43 Nm impact energy.

The test results are also sensitive to other factors such as:

1. Local variation in the sample. To minimize this it is recommended to take a selection of readings and take an average value.
2. Water content of the sample, a saturated material will give different results from a dry one.

Rebound hammer test (Schmidt Hammer) is used to provide a convenient and rapid indication of the compressive strength of concrete. It consists of a spring controlled mass that slides on a plunger within a tubular housing.

The operation of rebound hammer is as shown in the fig.2.1. When the plunger of rebound hammer is pressed against the surface of concrete, a spring controlled mass with a constant energy is made to hit the concrete surface and rebound back. The extent of rebound, which is a measure of surface hardness, is measured on a graduated scale. This measured value is designated as Rebound Number (rebound index). A concrete with low strength and low stiffness will absorb more energy to yield in a lower rebound value.

3.2.1 Principle of the Rebound Hammer Test:

Rebound hammer test method is based on the principle that the rebound of an elastic mass depends on the hardness of the concrete surface against which the mass strikes. When the plunger of rebound hammer is pressed against the concrete surface, the spring controlled mass in the hammer rebounds. The amount of rebound of the mass depends on the hardness of concrete surface. Thus, the hardness of concrete and rebound hammer reading can be correlated with compressive strength of concrete. The rebound value is read off along a graduated scale and is designated as the rebound number or rebound index. The compressive strength can be read directly from the graph provided on the body of the hammer. The rebound hammer is used in conduction with a calibrated chart. The chart is used to convert the rebound numbers to the estimated compressive strength.

The most suitable method of obtaining the correlation between compressive strength of concrete and rebound number is to test the concrete cubes using compression testing machine as well as using rebound hammer simultaneously. First the rebound number of concrete cube is taken and then the compressive strength is tested on compression testing machine. The fixed load required is of the order of 7 N/mm2 when the impact energy of the hammer is about 2.2 Nm. The load should be increased for calibrating rebound hammers of greater impact energy and decreased for calibrating rebound hammers of lesser impact energy. The test specimens should be as large a mass as possible in order to minimize the size effect on the test result of a full scale structure. 150mm cube specimens are preferred for calibrating rebound hammers of lower impact energy (2.2Nm), whereas for rebound hammers of higher impact energy, for example 30 Nm, the test cubes should not be smaller than 300mm.The concrete cube specimens should be kept at room temperature for about 24 hours after taking it out from the curing pond, before testing it with the rebound hammer. To obtain a correlation between rebound numbers and strength of wet cured and wet tested cubes, it is necessary to establish a correlation between the strength of wet tested cubes and the strength of dry tested cubes on which rebound readings are taken. A direct correlation between rebound numbers on wet cubes and the strength of wet cubes is not recommended. Only the vertical faces of the cubes as cast should be tested. At least nine readings should be taken on each of the two vertical faces accessible in the compression testing machine when using the rebound hammers. The points of impact on the specimen must not be nearer an edge than 20mm and should be not less than 20mm from each other. The same points must not be impacted more than once.

3.2.2. Interpretation of Rebound Hammer Test Results:
After obtaining the correlation between compressive strength and rebound number, the strength of structure can be assessed. In general, the rebound number increases as the strength increases and is also affected by a number of parameters i.e. type of cement, type of aggregate, surface condition and moisture content of the concrete, curing and age of concrete, carbonation of concrete surface etc. Moreover the rebound index is indicative of compressive strength of concrete up to a limited depth from the surface. The internal cracks, flaws etc. or heterogeneity across the cross section will not be indicated by rebound numbers.

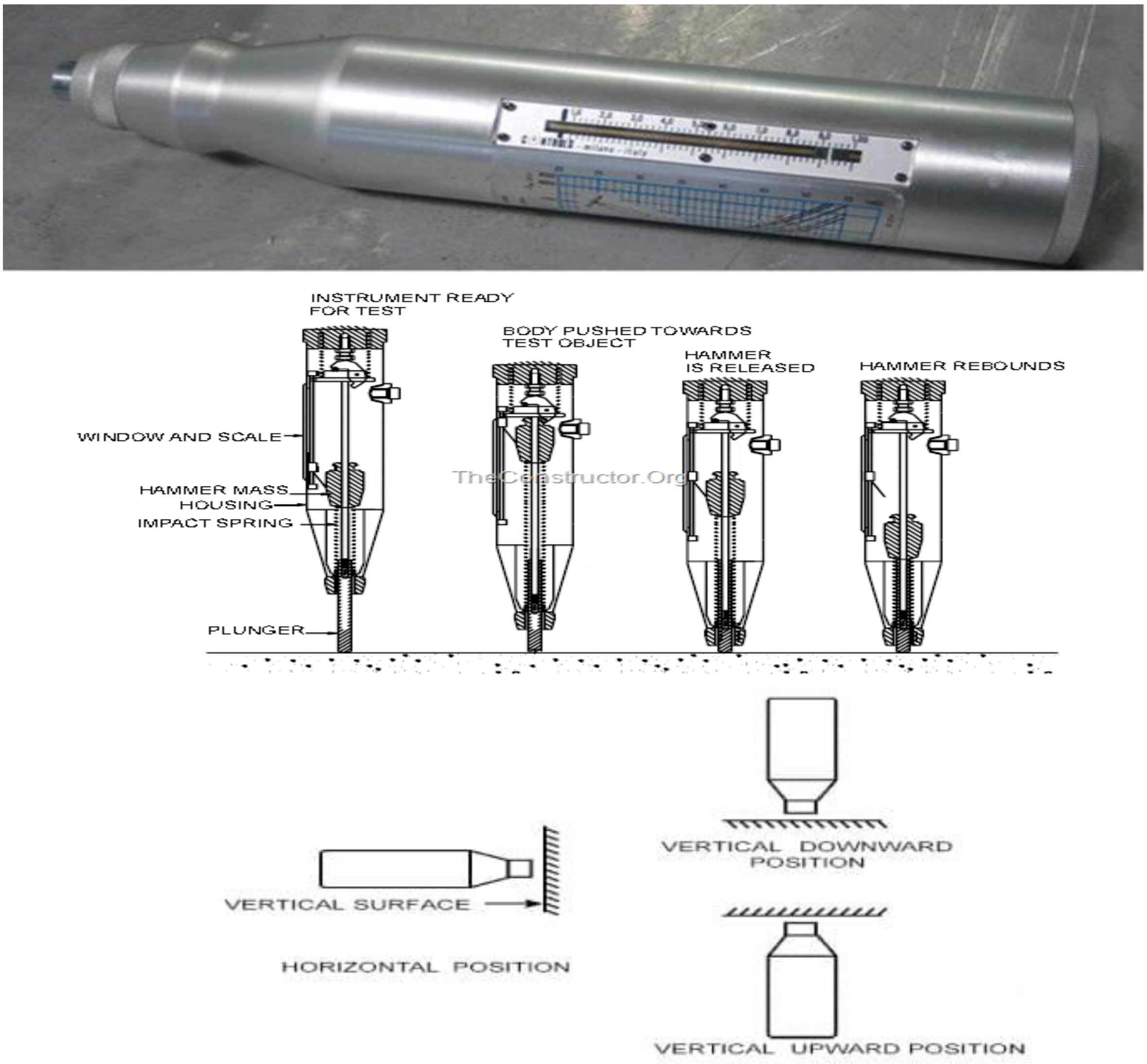


Figure 1: The rebound hammer and its operation

3.3 The Core Test.

In the core test, a coring machine was used to obtain core samples for laboratory test. Before the core test is carried out, a good study of the structural drawings is essential so as to ascertain the spaces between reinforcement bars in order to prevent cutting of the reinforcement bars during the coring process. Compressive Strength Test on Drilled Concrete Cores is required to determine the strength of hardened concrete in structure. The following are the specification for drilled concrete cores to be suitable for compressive strength test

Figure 2: Concrete Coring Machine

Figure 3: Floor Coring Operation Ongoing

Table 1: Correction factors for concrete core result

L/D Ratio	Correction Factor
1.75	0.98
1.5	0.96
1.25	0.93
1.0	0.87

3.3.1 Concrete Core Test

Testing of concrete core: Test the specimen within 7 days after coring. Calculation of compressive strength: Calculate the compressive test of the specimen using the computed cross sectional area based on average diameter of the specimen. If the L/D ratio is 1.75 or less, correct the result obtained by multiplying with correction factors as given below:

The value obtained after multiplying with correction factor is called corrected compressive strength, this being equivalent strength of a cylinder having L/D ratio of 2. The equivalent cube strength can be calculated by multiplying the corrected cylinder strength by 5/4.

3.3.2 Tensile Steel Test.

Three samples of each set of reinforcement bars were cut and taken to the laboratory for tensile steel test. A gauge length was determined (typically 50cm) and scribed into the Specimen so that the distance between the two marks could be measured after the tensile test was completed. The Blue Hill data acquisition software was started, and the correct material was chosen. The load cell was zeroed to ensure that the software only measured the tensile load applied to the specimen. The specimen was loaded into the jaws of the Instron load frame so that it was equally spaced between the two clamps.

The axial and transverse extensometers were attached to the reduced gauge section of the specimen, ensuring that the axial extensometer was set correctly when attaching it to the gauge and that the transverse extensometer was across the complete diameter of the specimen. This precaution results in better data and prevents damage to the extensometers.

The scroll wheel is to ensure that the specimen was properly loaded in the frame, and that it was not slipping in the jaws. The load was released, and the extensometers were zeroed using the software. The test was started, and the specimen was loaded, resulting in a measureable strain.

The data was gathered using the software, and loaded into a spreadsheet. At a set value of strain (past the yield strain), the software stopped using data from the extensometers, and started gathering the strain information using the position of the moving crosshead. A warning message came up on the computer screen, instructing the operator to remove the extensometers to prevent damage. The test continued until fracture, where the software stopped the moving crosshead, and finished gathering data. The specimen was removed, and the crosshead was reset to the position to start another tensile test. The testing procedure was repeated for the rest of the specimens

Figure 4: The Steel Tensile Test Machine

4. RESULT

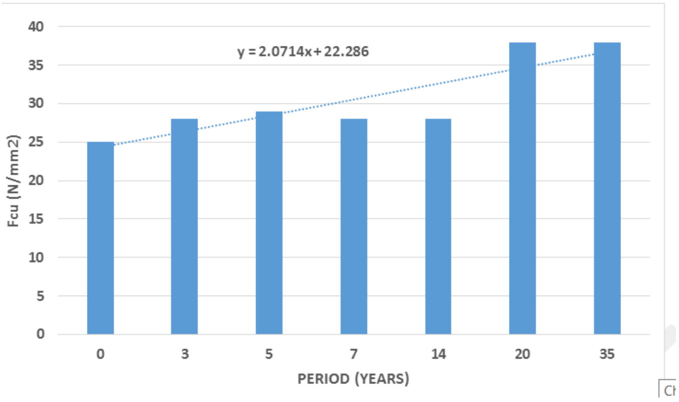
4.1 Concrete compressive strength result

From the series of the rebound hammer test carried out, the concrete strength of the various structural members were not affected, as most of them produced estimated characteristic compressive strength higher than the design characteristic strength. For all the structures used in this investigation, all vertical members (Columns and walls) were designed with grade 30 concrete, while the horizontal members (slabs and beams), were grade 25 concrete. The results are as shown in Figure 5.

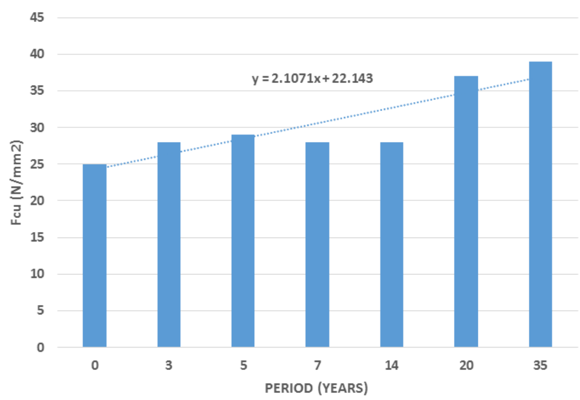
The graph above shows the various characteristic strength of concrete as a result of abandonment. As can be seen from the bar chart, the characteristic strength of the structural members under consideration increased with increase in age. This is an indication of good concrete quality control as at the time of construction.

4.2 Tensile Strength Test

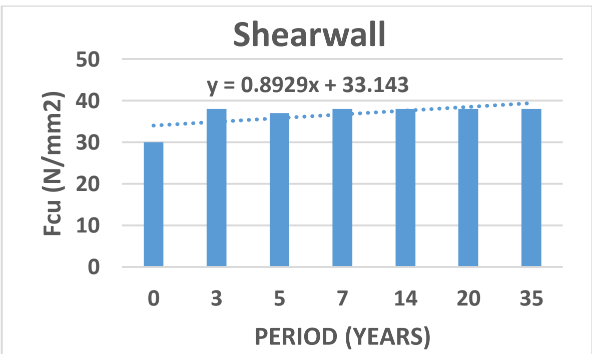
The tensile test result revealed a fall in the tensile strength of the tested reinforcement bars. The designed characteristic yield strength of 460N/mm², was used for the design. The strength acheived from the laboratory tensile test ranged between 456.09N/mm² and 267.45N/mm², an indication that the long term exposure to weather due to the abandonment has affected the reinforcement bars in strength. Figure 6 shows the tensile test result for the various period of abandonment.



(a) staircase



(b) slabs



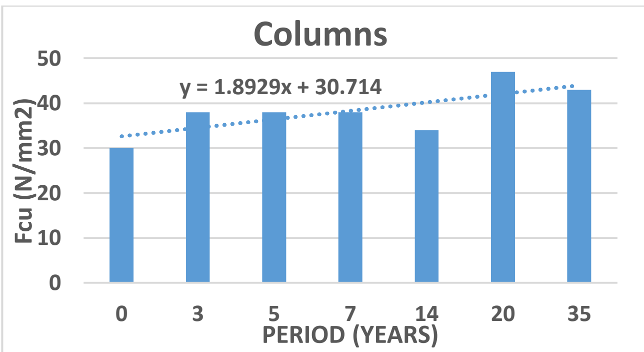


Figure 5: Effect of abandonment on various concrete structural members

4.3 Statistical analysis on the effect of abandonment on various sizes of reinforcement

From the data obtained, only the reinforcement bars deteriorated in strength as the period of abandonment increases. As such, a regression analysis was used to analyze the data. Microsoft Excel was then used to obtain the graphs that show the relationship between the period of abandonment and the characteristic strength of concrete. The R-Squared values and the corresponding equations are as shown in the graphs.

From Table 2 , the least R-square value is 0.6477, which implies that approximately 65% of the output variable variance is explained by the input variance. Also, the highest significant F value of 0.029, implies that there is only 2.9% that the regression output merely a chance occurrence. Also, the lower P-Values are indications that there are less probability that the regression output was merely a cahance occurrence.

Y = Characteristic tensile strength of steel in N/mm2:
X = period in years

Y12: Y= -0.0847X2-1.9101X+443.94

Y16: Y= -0.1698X2+1.531X+440.95

Y20: Y= -0.1076X2+0.5857X+448.61

Y25: Y= -0.1034X2+1.035X+448.08

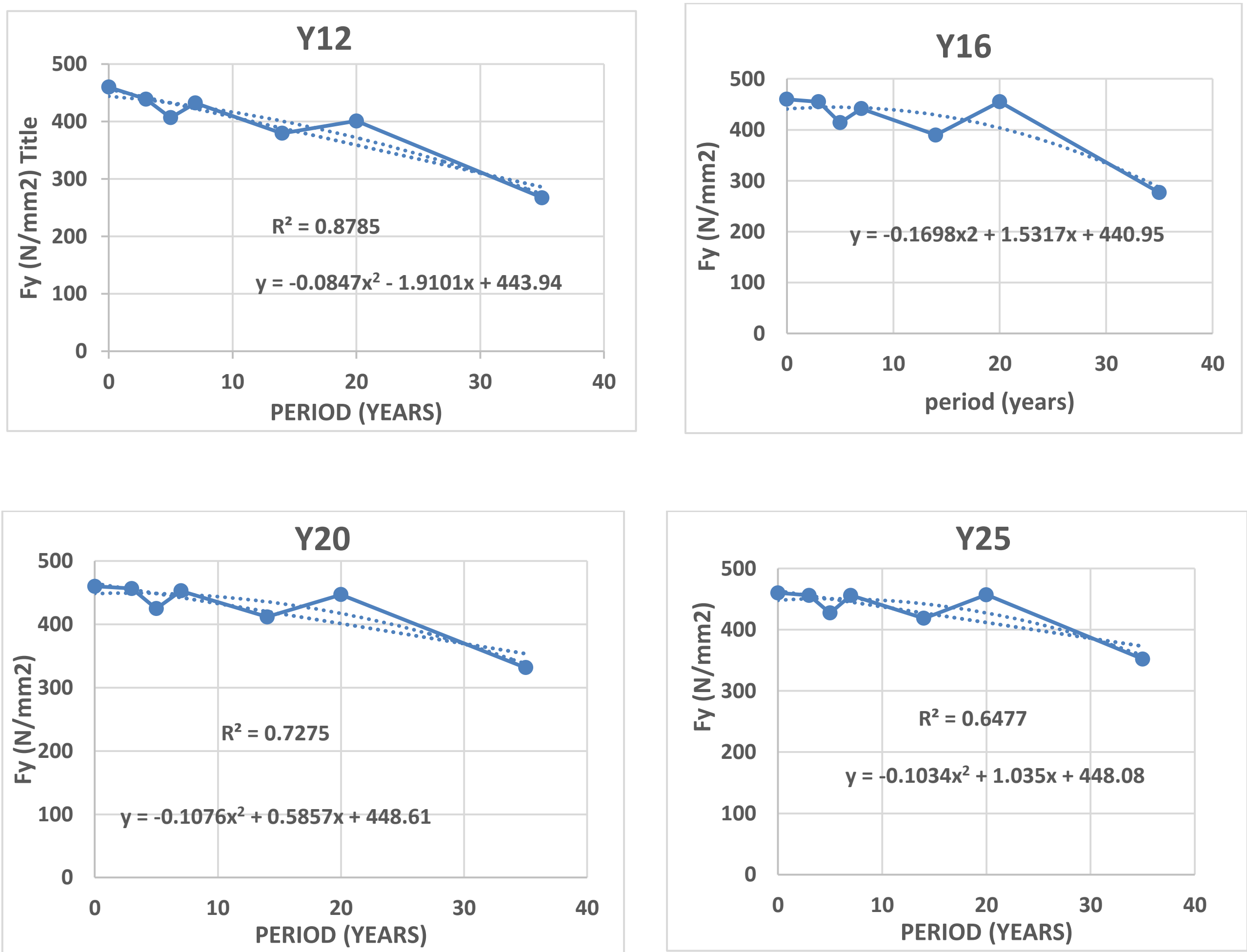


Figure 6: The effect of abandonment on various sizes of steel

Table 2: Regression values obtained for the various type of reinforcement bars.

	R-Square	Adjusted R-Square	Significant F	P-Value
Y12	0.8785	0.8541	0.0018	4.03E-07
Y16	0.6736	0.6084	0.0237	4.93E-06
Y20	0.7275	0.6730	0.0147	5.22E-07
Y25	0.6477	0.5772	0.0290	4.75E-07

5. CONCLUSION

In conclusion, for abandoned reinforced concrete structure, within the Southern region of Nigeria where the temperature ranges between 23°C and 32°C and precipitation/rainfall ranged between 36mm and 410mm, the concrete members will be unaffected by weather and its compressive strength will rather increase than decrease. As for the exposed steel reinforcement bars, the effect of weather will cause deterioration and as such, reduce the tensile strength of the exposed reinforcement bars, thus making them unfit to continue the structure. The rate of deterioration varies with different sizes of reinforcement bars and with time.

6. RECOMMENDATION

Abandoned concrete will not deteriorate in strength except when at the construction stage, poor concrete quality control was maintained. As such, good quality control and workmanship in concrete preparation, transportation and placement should be ensured at the construction stage. Good workmanship reduces cracks, ensures adequate cover to reinforcement bars amongst others. Deteriorated exposed reinforcement bars, should be wire brushed and doubled or embedded unaffected reinforcement bars should be exposed to the required lap length before the continuation of the project. Also, the structure can be re-designed with the new tensile strength and the reinforcement bars placed as specified by the new design

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