Journal of Physical Science and Environmental Studies
Vol. 12 (5), pp. 98-104, November 2026
ISSN 2467-8775
Research Paper
https://doi.org/10.36630/jpses_26022
http://pearlresearchjournals.org/journals/jpses/index.html

©2026 Pearl Research Journals

Implementation of Structural Details and Safety Considerations in the Use of Reinforcement Bars in Buildings in Owerri Metropolis, Nigeria

Uche Felix Ikechukwu[1], Emeka Richard Madukwe[2], and Ugonna Ikechukwu Oguzie[1]

Accepted 25 October, 2026

[1]Department of Building, Imo State University Owerri, Nigeria.
[2]Department of Building, Abia State University Uturu, Nigeria.

ABSTRACT

The benefits of effective structural design cannot be fully realised without proper implementation of the details contained in the design. Many structures with sound designs have failed due to poor implementation of reinforcement details, resulting in loss of lives and property in Owerri Metropolis and Nigeria at large. This study evaluated the use and placement of reinforcement bars in structural components with a view to enhancing safety and structural integrity. A combination of literature review and field survey was adopted. Data were collected through purposive sampling of 30 building production professionals (12 Structural Engineers, 12 Builders, and 6 Architects) in Owerri Metropolis. The data were analysed using mean score ranking, descriptive statistics, and inferential statistics. The Kruskal-Wallis H-test was used to examine differences among the five types of reinforcement bars, while the Chi-square (χ^2) test was used to assess the association between factors of poor implementation and structural integrity. Findings revealed that High Yield Strength Deformed (HYSD) bars recorded the highest mean score for tensile strength (M/S = 3.50). However, the Kruskal-Wallis test ($H = 7.280$, $p > 0.05$) indicated no statistically significant difference among the five common types of reinforcement bars. Ineffective supervision (M/S = 3.10) and non-compliance with structural details (M/S = 3.07) ranked as the leading factors responsible for poor implementation. The Chi-square test ($\chi^2 = 96.15$, $p < 0.05$) confirmed that these factors have a significant effect on the integrity of structural components. Hand gloves (M/S = 3.73), safety boots (M/S = 3.60), and hard hats (M/S = 3.33) were identified as the most significant personal protective equipment. The study concludes that non-compliance with codes of practice, inadequate supervision, and engagement of inappropriate professionals remain critical threats to the performance of reinforced concrete structures. It is recommended that relevant authorities enforce proper certification of structural drawings, the Standards Organisation of Nigeria (SON) should intensify quality control of reinforcement bars in open markets, and the provisions of the National Building Code regarding the engagement of qualified professionals should be strictly implemented.

Keywords: Reinforced concrete component, structural details, reinforcement bars, placement of rebar, of structural integrity , safety.

*Corresponding author. Email: uchehappy4me@gmail.com

INTRODUCTION

Structural detailing is a critical component of effective structural design. When a structural engineer accounts for environmental conditions, material efficiency, adaptability, strength, and durability, the resulting design can be regarded as sustainable (Douglas, 2002). Structural elements such as slabs, beams, columns, load-bearing walls, and foundations form the framework that ensures the stability and safety of a building. For these elements to perform as intended, structural drawings must provide clear specifications on the quantity, location, position, lap lengths, bending schedules, and connections of reinforcement bars (Roy and Roger, 2009).

Reinforced concrete relies on steel reinforcement bars (rebars) to resist tensile forces that plain concrete cannot effectively carry. Several types of rebars are commonly used in construction, including mild steel, carbon steel, epoxy-coated bars, galvanised steel bars, and high-yield strength deformed (HYSD) bars. Among these, HYSD bars, particularly the thermo-mechanically treated (TMT) variety, are widely preferred because of their superior tensile strength, ductility, elongation, weldability, and improved bond with concrete (Roy and Roger, 2009; BSI, 2007). Proper storage, handling, and placement of these bars are essential. Bars must be stored in dry conditions to prevent corrosion, correctly cut and bent according to bending schedules, and positioned with adequate spacing and concrete cover to ensure durability, fire resistance, and effective stress transfer (Gahlot and Sanjay, 2017; CORBON, 2013).

Even a well-designed structure can lose its intended integrity and service life if the wrong type of rebar is selected, if bars are incorrectly placed, or if construction practices deviate from the approved details. In the Nigerian construction industry, common problems include non-compliance with structural drawings, inadequate supervision, engagement of unqualified personnel, and poor site safety practices. These issues often

result in material wastage, rework, structural cracks, reduced durability, and, in severe cases, building collapse (Chukwuji and Ukah, 2022; Nsikak et al., 2022). Safety during reinforcement works is equally critical. The consistent use of appropriate personal protective equipment (PPE), such as safety boots, hard hats, hand gloves, and eye protection, is necessary to minimise site accidents (CORBON, 2013).

Relevant codes and standards provide guidance for achieving structural integrity and safety. These include ACI 318-19 (ACI, 2019), BS 8110-1 (BSI, 2007), Eurocode 2 (CEN, 2004), the National Building Code (2006), and the CORBON Health and Safety Manual (2013). Compliance with these documents is essential for ensuring that reinforced concrete structures perform as designed throughout their service life.

This study therefore examines the implementation of structural details with particular emphasis on the use and placement of reinforcement bars in buildings within Owerri Metropolis, Imo State, Nigeria. The specific objectives of the study are to:

i. Evaluate the performance characteristics of commonly used reinforcement bars (mild steel, carbon steel, epoxy-coated, galvanised, and high-yield strength deformed bars);

ii. Identify the major factors responsible for poor implementation of structural details and assess their effect on the integrity of structural components

iii. Examine the significance of various types of personal protective equipment (PPE) in the safe handling and placement of reinforcement bars.

METHODOLOGY

Research Design

The study adopted a mixed approach comprising a review of relevant literature and codes of practice, and a field survey. The survey component was designed to obtain the opinions of key building production professionals on the performance of different types of reinforcement bars, the factors responsible for poor implementation of structural details, and the significance of personal protective equipment (PPE) during the handling and placement of reinforcement bars.

Study Area

The study was conducted in Owerri Metropolis, Imo State, Nigeria. The choice of this location was informed by the increasing incidence of structural defects and reported cases of non-compliance with structural drawings in building construction projects within the metropolis.

Population and Sampling Technique

The target population comprised registered building production professionals practising in Owerri Metropolis, specifically Structural Engineers, Builders, and Architects. A purposive sampling technique was employed to select respondents who were actively involved in the design, supervision, or construction of reinforced concrete structures. The sample consisted of 30 professionals: 12 Structural Engineers, 12 Builders, and 6 Architects (Chukwuji & Ukah, 2022).

Data Collection Instrument

Primary data were collected through a structured questionnaire. The questionnaire was designed on a 4-point Likert scale with the following weights: Strongly Agree (SA) = 4, Agree (A) = 3, Disagree (D) = 2, and Strongly Disagree (SD) = 1.

The instrument was divided into sections corresponding to the three research objectives:

- Performance characteristics of five common types of reinforcement bars (mild steel, carbon steel, epoxy-coated, galvanised, and high-yield strength deformed bars);
- Factors contributing to poor implementation of structural details; and
- Significance of various types of personal protective equipment (PPE) used during reinforcement works.

Method of Data Analysis

Data were analysed using both descriptive and inferential statistics. Descriptive statistics involved the calculation of mean scores. The mean score (M/S) for each item was obtained by dividing the total weighted score by the number of respondents (30). A mean threshold of 2.50 was adopted as the decision criterion for acceptance or rejection of an item (BSI, 2007; Nsikak et al., 2022). Inferential statistics were applied to test the hypotheses of the study. The Kruskal-Wallis H-test was used to examine whether significant differences existed among the five types of reinforcement bars with respect to the measured performance characteristics. The Chi-square (χ^2) test was employed to determine whether the identified factors of poor implementation had a statistically significant effect on the integrity of structural components. All tests were conducted at the 0.05 level of significance.

RESULTS AND DISCUSSION

Data obtained from the survey of 30 building production professionals in Owerri Metropolis are presented and discussed in this section according to the three research objectives. A 4-point Likert scale was used, with mean scores (M/S) calculated as Total Weighted Score ÷ Number of Respondents (30). A mean threshold of 2.50 was adopted for acceptance.

Objective i: Performance Characteristics of Various Types of Reinforcement Bars

Table 1 presents the respondents' assessment of five common types of reinforcement bars based on tensile strength, ductility, resistance to corrosion, and elongation and weldability.

From Table 1, the tensile strength of HYSD bars ranked highest (M/S = 3.50), followed by the tensile strength of carbon steel bars (M/S = 3.43). The lowest mean score was recorded for the ductility of carbon steel bars (M/S = 2.07). These findings are consistent with Roy and Roger (2009) and BSI (2007), which affirm that HYSD bars, particularly the thermo-mechanically treated (TMT) type, possess superior tensile strength and bond characteristics due to their ribbed surface.

A Kruskal-Wallis H-test was conducted to determine whether the observed differences among the five rebar types were statistically significant. The calculated H-value was 7.280. At the 0.05 significance level with 4 degrees of freedom, the critical Chi-square value is 9.488. Since H-calculated (7.280) is less than the critical value (9.488), the null hypothesis is retained. This indicates that, although descriptive differences exist, the variations in performance characteristics among the

Table 1: Performance Characteristics of Various Types of Reinforcement Bars.

S/n	Types of Bar	SA (4)		A (3)		D (2)		SD (1)		Total	M/S	Rank
		X	fX	X	fX	X	fX	X	fX			
A	**Mild Steel**											
i	Tensile Strength	10	40	9	27	5	10	6	6	83	2.77	10th
ii	Ductility	8	32	10	30	6	12	6	6	80	2.67	13th
iii	Resistance to Corrosion	16	64	7	21	2	4	5	5	94	3.13	5th
iv	Elongation Potential and Weld-ability	7	28	8	24	10	20	5	5	77	2.57	14th
B	**Carbon Steel**											
i	Tensile Strength	18	72	5	15	7	14	2	2	103	3.43	2nd
ii	Ductility	6	24	2	6	10	20	12	12	62	2.07	20th
iii	Resistance to Corrosion	4	16	9	27	11	22	6	6	71	2.37	18th
iv	Elongation Potential and Weld-ability	6	24	8	24	9	18	7	7	73	2.43	16th
C	**Epoxy Coated Bar**											
i	Tensile Strength	8	32	7	21	6	12	9	9	74	2.47	15th
ii	Ductility	15	60	9	27	5	10	1	1	98	3.27	3rd
iii	Resistance to Corrosion	11	44	8	24	9	18	2	2	88	2.93	8th
iv	Elongation Potential and Weld-ability	13	52	3	9	6	12	8	8	81	2.70	12th
D	**Galvanized Steel Bar**											
i	Tensile Strength	13	52	7	21	6	12	4	4	89	2.97	7th
ii	Ductility	7	28	7	21	5	10	11	11	70	2.33	19th
iii	Resistance to Corrosion	13	52	10	30	4	8	3	3	93	3.10	6th
iv	Elongation Potential and Weld-ability	6	24	8	24	8	16	8	8	72	2.40	17th
E	**High Yield Strength Deformed Bar**											
i	Tensile Strength	19	76	7	21	4	8	0	0	105	3.50	1st
ii	Ductility	10	40	7	21	8	16	5	5	82	2.73	11th
iii	Resistance to Corrosion	15	60	3	9	5	10	7	7	86	2.87	9th
iv	Elongation Potential and Weld-ability	16	64	8	24	3	6	3	3	97	3.23	4th

Source: Field Survey Results (2025).

five types of reinforcement bars are not statistically significant in the study area. The result suggests that all five types can meet minimum structural requirements when correctly specified and properly implemented in accordance with relevant codes (ACI, 2019; BSI, 2007; CEN, 2004).

Objective ii: Factors Leading to Poor Implementation of Structural Details

Table 2 presents the factors identified as contributing to poor implementation of structural details.

Table 2: Factors Leading to Poor Implementation of Structural Details.

S/n	Variables	SA (4) X	fX	A (3) X	fX	D (2) X	fX	SD (1) X	fX	Total	M/S	Rank
A	Poor Structural Design and Details	3	12	5	15	2	4	20	20	51	1.7	5th
B	Negligence and Non Compliance	14	56	7	21	6	12	3	3	92	3.07	2nd
C	Wrong Professional Engagement in Building Production	9	36	12	36	8	16	1	1	89	2.97	3rd
D	Ineffective Supervision of Work	13	52	10	30	4	8	3	3	93	3.10	1st
E	Wrong Interpretation of Details	10	40	8	24	6	12	6	6	82	2.73	4th

Source: Field Survey Results (2025)

Table 3: Significance of Various Types of Personal Protective Equipment (PPE).

S/n	Variables	SA (4) X	fX	A (3) X	fX	D (2) X	fX	SD (1) X	fX	Total	M/S	Rank
A	Hard Foot Wear	21	84	6	18	3	6	0	0	108	3.60	2nd
B	Hard Hat	17	68	9	27	1	2	3	3	100	3.33	3rd
C	Hand Glove	24	96	5	15	0	0	1	1	112	3.73	1st
D	Eye Goggle	11	44	7	21	9	18	3	3	86	2.87	4th
E	Overall Clothe	5	20	8	24	16	32	1	1	77	2.57	5th

Source: Field Survey (2025).

Ineffective supervision of work ranked highest (M/S = 3.10), followed closely by negligence and non-compliance (M/S = 3.07). Poor structural design and details ranked lowest (M/S = 1.70), indicating that respondents largely disagreed that design deficiencies were the primary problem. This finding supports the position of CORBON (2013) and Nsikak et al. (2022) that the major challenges in reinforced concrete construction often lie in implementation rather than in the design itself.

A Chi-square test was performed to examine the relationship between these factors and the integrity of structural components. Using the observed frequencies, the calculated Chi-square value was 96.15. At the 0.05 significance level with 12 degrees of freedom, the critical value is 21.03. Since χ^2-calculated (96.15) is greater than the critical value (21.03), the null hypothesis is rejected. It is therefore concluded that the factors leading to poor implementation of structural details have a statistically significant effect on the integrity of structural components in Owerri Metropolis. This result is consistent with the findings of Chukwuji and Ukah (2022) and CORBON (2013).

Objective iii: Significance of Various Types of Personal Protective Equipment (PPE)

Table 3 shows the respondents' assessment of the significance of different types of PPE during the handling and placement of reinforcement bars.

Hand gloves ranked highest (M/S = 3.73), followed by safety boots (M/S = 3.60) and hard hats (M/S = 3.33). Overall clothing recorded the lowest mean score (M/S = 2.57). All five types of PPE recorded mean scores above the acceptance threshold of 2.50, indicating that respondents considered them important for safety during reinforcement works. These findings align with the requirements of the CORBON (2013) Health and Safety Manual and ISO 45001.

CONCLUSION

This study assessed the implementation of structural details with emphasis on the use and placement of reinforcement bars in buildings within Owerri Metropolis, Nigeria. The investigation was guided by three objectives and relevant codes of practice, including ACI 318-19, BS 8110-1, Eurocode 2, the National Building Code (2006), and the CORBON Health and Safety Manual (2013).

The findings revealed that High Yield Strength Deformed (HYSD) bars, particularly the thermo-mechanically treated (TMT) type, were rated highest in tensile strength (Mean Score = 3.50) and elongation and weldability (Mean Score = 3.23). Although descriptive differences existed among the five types of reinforcement bars examined, the Kruskal-Wallis test showed that these differences were not statistically significant ($H = 7.280 < 9.488$, $p > 0.05$). This suggests that all the rebar

types can perform adequately when they conform to standard specifications and are correctly implemented. In contrast, factors associated with poor implementation of structural details were found to have a significant effect on the integrity of structural components ($\chi^2 = 96.15 > 21.03$, $p < 0.05$). Ineffective supervision (Mean Score = 3.10) and negligence/non-compliance (Mean Score = 3.07) ranked as the most critical problems, while poor structural design itself was rated least important (Mean Score = 1.70). This indicates that the major challenges in the study area relate more to implementation practices than to design deficiencies.

All categories of personal protective equipment examined were considered important for safety during reinforcement works, with hand gloves (Mean Score = 3.73), safety boots (Mean Score = 3.60), and hard hats (Mean Score = 3.33) ranking highest. Overall, the study concludes that while the choice of reinforcement bar is important, proper implementation of structural details, effective supervision, compliance with specifications, and consistent use of PPE are more critical to achieving structural integrity and safety in building construction within Owerri Metropolis.

RECOMMENDATIONS

Based on the findings of the study, the following recommendations are made:

i. Regulatory agencies such as the Owerri Capital Development Authority (OCDA) and the Standards Organisation of Nigeria (SON) should strengthen enforcement of ethical standards and quality control in the design, approval, and construction of buildings to minimise negligence and compromise of structural quality.

ii. The government should intensify efforts to monitor and regulate the quality of reinforcement bars sold in open markets within Owerri Metropolis. Particular attention should be given to the common practice of reducing bar diameters (for example, selling 11.5 mm bars as 12 mm).

iii. Only registered and qualified professionals — Structural Engineers, Builders, and Architects — should be engaged to interpret and supervise the implementation of structural drawings, in line with the National Building Code (2006) and CORBON regulations.

iv. Government should introduce and enforce appropriate sanctions against individuals and organisations that violate codes of practice in the manufacture, supply, and use of reinforcement bars.

v. Construction stakeholders, in collaboration with the Nigerian Institute of Building (NIOB) and the Council of Registered Builders of Nigeria (CORBON), should support continuous training and retraining of site personnel. Regular toolbox talks on the proper use of personal protective equipment should be made mandatory on all construction sites.

SUGGESTIONS FOR FURTHER STUDIES

Future research should consider the following:

i. Increasing the sample size beyond 30 respondents to improve the generalisability of findings.

ii. Conducting laboratory tests on the actual tensile strength and other mechanical properties of HYSD bars available in Owerri markets to verify compliance with BS 4449 and SON standards.

iii. Applying alternative statistical techniques, such as the Friedman test, for more robust analysis of ranked data.

REFERENCES

American Concrete Institute – ACI (2019) Building Code Requirements for Structural Concrete and Commentary. American Concrete Institute, Farmington Hills, Michigan.

British Standard Institute – BSI (2007). Structural Use of Concrete – Part 1: Code of Practice for Design and Construction. British Standard Institution, London.

Canadian Standard Association – CSA (2004). Design of Concrete Structures, Ottawa, Canada.

Chukwuji CFM and Ukah GC (2022). The Practice of Building Profession. CEL-BEZ Publishing Company Nig. Ltd. Owerri, Imo State, Nigeria.

Council of Registered Builders of Nigeria – CORBON (2013). Health and Safety Manual for Nigeria Building Industry. Council of Registered Builders of Nigeria. Abuja.

Douglas J (2002). Building Adaptation. Butter-worth Heineman, New Delhi, India.

European Committee for Standardization – CEN (2004). Euro-code 2: Design of Concrete Structures. General Rules and Rules for Building Structures. Brussels, Belgium.

European Committee for Standardization – CEN (2010). Basis for Structural Design – Eurocode. Brussels, Belgium.

Garhlot PS and Sanjay S (2017). Building Repairs and Maintenance Management. CBS Publishers Pvt. New Delhi, India.

Nsikak WU, Odesola IA, Umoh AA (2022). Post Punching and Progressive Collapse of Reinforced Concrete Flat Slabs: Evaluation of Design Code Recommendations. Journal of the Nigeria Institute of Building, 7(1): 90-109

Roy C and Roger G (2009). Construction Technology – 4th Edition. Pearson Education Ltd. Edinburgh Gate, Harlow, England.