

Reinforced Concrete Pole as Structural Support and Fault Minimization in Radial Electrical Distribution System in Yobe State

Hassan Adamu Daya^{1*}, Haruna Mohammed², Mohammed Abubakar Sadiq³, Yusuf Musa Yerima⁴

Department of Electrical and Electronics Engineering^{1,2&3}, Department of Civil Engineering⁴, Mai Idris Aloom Polytechnic, Geidam

*Corresponding author: email kintinkisah@gmail.com, phone number: +2348069720321

Abstract: Reinforced concrete poles (RCPs) have emerged as a robust solution for enhancing structural support and minimizing faults in radial electrical distribution systems in Yobe state. These faults, characterized by their composite construction of steel-reinforced concrete, offer superior durability, high load-bearing capacity, and resistance to environmental stressors such as corrosion, termites, fire, and extreme weather. In radial systems, where power flows unidirectional from the substation to end users, the structural integrity of support poles is crucial for maintaining uninterrupted service. These studies examine how RCPs mitigate both structural and electrical faults by preventing pole failures that lead to line collapses, sagging, or contact with vegetation.

Key words: *Reinforced, Radial, Support, Structural, Concrete, Pole, Distribution.*

1. INTRODUCTION

The radial electrical distribution system, while cost-effective for the vast and often rural terrain of Yobe State, is highly vulnerable to single-point failures. A fault on any segment of the line can lead to a cascading power outage for all downstream consumers. A significant portion of these faults is structural in nature, directly linked to the failure of pole supports. The predominant use of wooden and, in some older sections, steel poles has proven inadequate for the unique environmental challenges of Yobe. The seasonal Harmattan winds and sudden dust storms exert substantial lateral forces, causing wooden poles to snap and steel poles to corrode and weaken at the base. Wooden poles are highly susceptible to termite infestations, compromising their structural integrity from the inside out and leading to sudden, unexpected collapse. Dry-season bushfires can quickly destroy wooden poles, exacerbating the risk of widespread outages. Steel poles are often targeted for theft, leaving entire sections of the distribution line vulnerable to damage. These factors contribute to a high Fault Frequency Rate, resulting in an unreliable power supply, economic losses, and social inconvenience.

This research paper's strategic shift towards using Reinforced Concrete (RC) Poles as the primary structural support in our ongoing network rehabilitation and expansion projects, and the impacts of the failure of reinforced concrete electric poles, aims to articulate the standard requirements for fabricating and installing poles in Yobe State. A modern electrical distribution system is the backbone of societal infrastructure, delivering power from generation sources to end users with an expectation of reliability and safety. Among these systems, radial electrical distribution networks, characterized by unidirectional power flow from a single substation to consumers, are widely adopted due to their simplicity and cost-effectiveness. However, their

linear architecture makes them inherently vulnerable to cascading failures if a critical component, such as support poles, degrades or collapses. Traditional materials like wood and steel, historically used for utility poles, face significant challenges, including susceptibility to environmental degradation (e.g, rot, corrosion, termite infestation), mechanical fatigue, and electrical faults caused by conductive properties or poor grounding.

Radial electrical distribution systems, particularly in regions like Geidam Yobe, Nigeria, face persistent challenges that compromise their efficiency and reliability. A key issue is the vulnerability of the structural supports for overhead power lines. Traditional wooden poles, commonly used, are susceptible to: Deterioration, Environmental Factors, Limited Lifespan, and Inadequate Strength. This research will be limited to Yobe State and will cover selected local government areas as a sample of the study; these selected local government areas are Geidam, Potiskum, and Damaturu.

Research indicates that the manufacturing of reinforced concrete poles is adversely impacted by the use of substandard materials, particularly concrete (Illochi E. E, et al, 1994). The compressive behavior of concrete, is initially linear and elastic, allowing for complete recovery from deformation. Beyond this elastic limit, its behavior becomes plastic, leading to irreversible deformation. Mosely, H.M., et al, (1999) The ultimate strain capacity of structural concrete remains approximately 0.0035, independent of the concrete's load-dependent strength, the strength of these electric concrete poles and the loads applied to them are critical and must be assessed. The British Standards Institution (1997) mandates that if an inspection by an authorized person determines that a pole is unsafe, unstable, improperly installed, or officially condemned, climbing and stripping the pole are prohibited. The only exception is if

Reinforced Concrete Pole as Structural Support and Fault Minimization in Radial Electrical Distribution System in Yobe State

the pole is first adequately stayed or supported, as specified in section 12 of the design code.

British Standard Institution (1970) outlines that concrete poles, or light standards, are engineered to meet specific environmental loads and aesthetic criteria. Their design and application are governed by a framework of standards and codes, including those from AASHTO and ANSI, as well as local regulations. These guidelines, grounded in theoretical analysis, research, and industry practice, mandate consideration of multiple factors. These include wind-induced stresses (such as bending and shear), secondary moments from pole deflection, and thermal effects on the base material. Consequently, selecting an appropriate pole requires a comprehensive assessment of all these variables against actual field conditions.

The design, materials, and construction methods for concrete poles are fundamentally determined by the loads they must support (Levy, M, and Salvadori, M, 2002). Crucially, understanding how these loads are transferred during both construction and structural modifications is vital. Specifically, the poles must be sufficiently strong to withstand three primary load categories: static, dynamic, and hidden loads. Wearne, P. (1999) define dynamic loads as those applied suddenly, including forces from high winds and seismic activity. Boal, G.A. (1981) mandates that concrete utility poles must be installed to a sufficient standard to prevent collapse and the resultant damage. The relationship between structural integrity and power system reliability is fundamental. Shehata, A.Y, et al, (2005) Mechanical stress, arising from sources such as vibration, dynamic wind loads, or improper manufacturing, is a known precursor to both intermittent and hard failures in distribution components. According to Australian Energy report (2025) Structural reliability analysis assesses various limit states, including yielding, buckling, fatigue, and excessive deformations.

Johanneson P, et al (2022) For utility supports, the ultimate limit state (catastrophic collapse) instantly compromises the electrical network, triggering prolonged and extensive outages. Standard Guide for Specification PIC (2008). Infrastructure hardening, specifically the replacement of vulnerable assets with stronger materials, has been demonstrated internationally as a critical strategy to enhance network resilience against extreme weather events and reduce outage duration. This study aims to investigate the causes and impacts of failure of reinforced electric concrete poles and to articulate the standard requirements for fabricating and installing poles used in Yobe State.

2.0 Investigation of Failure of Reinforced Concrete Poles.

Investigation into the failure of these reinforced concrete poles revealed that more than 80% of all weather-related line failures are caused by High Intensity Winds (HIWS), ranging from fully mature tornadoes to various forms of gusts and microbursts associated with thunderstorms Australian Energy report (2025). There are many examples of failure of these poles due to high wind-induced oscillations, indicating that the engineer/Technician installing them lacked knowledge of the effects of wind.

In their studies Johanneson P, etal (2022), they stated that the gust wind velocity is converted to loads acting on a converter pole using appropriate load factors, and that the resulting loadings on the reinforced concrete poles are determined using loading coefficients currently taken from design codes of practice. Wind effects on reinforced concrete poles under the buffeting action of wind gusts have traditionally been treated by the “Gust Loading Factor (GLF) method in most major codes and standards around the world”. In this scheme, the equivalent static wind loading used for design is equal to the mean wind force multiplied by the GLF.

Reinforced Concrete Pole as Structural Support and Fault Minimization in Radial Electrical Distribution System in Yobe State

2.1 Wind Effect

Using sustainable, high-quality raw materials is also very important when manufacturing concrete poles. These concrete poles are widely used in various communities and industries (Shalaby, A.M, 2011). One of the major, if not the greatest, difficulties in developing a wind loading code is accounting for load fluctuations due to gustiness (a Sudden rush of wind), their non-simultaneous occurrence, and their effects on humans, which are not suitable. The most convenient way is to include these in an equivalent static load (Niemann, H.J. 2004). Introduced by the American Society of Civil Engineers (1987) the wind directionality factor enables the calculation of design wind speeds for each wind direction, thereby facilitating rational design that considers the orientation of reinforced concrete with respect to wind direction. Moreover, a new topographic factor for turbulence intensity has been added to account for increased fluctuating wind speed. The effect of winds is stipulated in ASCE (1989). For most reinforced concrete poles, wind loads can be treated as static loads and are computed using reference velocity pressures, gust factors, exposure factors, and shape factors. These reinforced concrete poles and their

components are to be designed to withstand the code-specified wind loads. Calculating the wind force-resisting system.

2.2 Specification

In agreement with Standard Guide for Specification PIC (2008), which stipulated that concrete poles are also specified in areas of chemical contamination and pollution that may cause rapid deterioration, especially wood poles.

According to Levy, M, and Salvadori, M (2002), in special situations where poles of unusually high strength are required, stresses imposed on concrete poles will be calculated as if they were continuous beams fixed at one end. These values, with proper factors of safety applied, were used to select the pole. The forces acting on a pole are due to the vertical loading (including the Dead weight of conductors). Horizontal loading (due to wind pressure on conductors and poles) usually overshadows vertical loading to the extent that it may not be given further attention. For horizontal loading, the pole can be considered as a cantilever beam anchored at one end Standard Guide for Specification PIC (2008). The bending moment produces stresses in the concrete, with the maximum fibre stress occurring at the edge of the cross-section, far from the neutral axis. The stresses are compressive on the side on which the load is pulling and tensile on the opposite side. BS 607 Part 2 specified the minimum ultimate transverse load for different pole classes, as shown in

Table 1:Rural Utilities Service Construction Standard (RUS)

Class of poles	Minimum Ultimate Transverse Loads at 0.6 N from top (KN)
1	2.8
2	3.9
3	5.6
4	7.8
5	11.1
6	15.6

Source: [13] Table 1 shows the Minimum Ultimate Transverse Loads MUTLS)

Table 2: Standardized Types/Sizes of Reinforced Concrete Poles.

Standardized Types/Sizes of reinforced concrete poles Height of Poles Meter(m)	Buried length Mete(m)	Working Load (Kg)	Purpose
6.0	1.40	50	Insulated wire service connection
8.3	1.40	100	LV lines (without street lamp wire)
9.0	1.5	115	LV lines (Self-supporting pole)
10.0	1.7	300	(i) Only MV line (ii) Combined run (iii) MV and LV on the same pole.

Source: [14] LV= Low Voltage, MV= Medium Voltage

2.3 Petrographic Analysis

Levy, M, and Salvadori, M (2002), provided an analysis on how to determine physical irregularities in concrete through observation. This type of analysis was used to determine the strength, mixture proportion estimate (e.g., water-cement ratio), and corrosion potential of embedded steel. This type of information can help identify the root cause of failure and assess the extent of cracking, dusting, scaling, or coating in reinforced concrete poles. Standard Guide for Specification PIC (2008)., stated that before the installation of poles, checks for damage, such as cracking and spalling, are in place. And if any is discovered, it should be replaced. It was further explained that sections deep enough to expose reinforcing steel should also be replaced.

2.4 Why Do Concrete Poles Fail

Fresh concrete is a transient material with continuously changing properties. It has been discovered that concrete is a plastic material and not elastic, so the corrosion of the steel reinforcing bars almost always causes the failure of reinforced concrete poles. In most cases,

reinforcing bars are used without any protective coating and rely on the passivation of their surface by the highly alkaline cement. When steel and concrete are used together, they exhibit the same behaviour Materials Specifications for steel poles and base mounting (2012). Reinforced concrete poles utilize additional materials, such as steel bars, wooden beams, or fibres, along with a wire frame to help shape the concrete. The reinforcement interacts with the concrete, strengthening it and providing sufficient support. The concrete offers adequate shielding to the steel, preventing it from corroding as quickly, and together they are a common component in modern construction David Corractine, et al, (2008). Conductor weight loads will increase due to the effect of increased tension on poles with a height profile above the average of neighbouring poles; however, in general, this factor is pretty minimal in relatively flat terrain. Note that the wind effect on the pole constitutes the environmental load on the poles David C., et al, (2008).

2.5 Essential Considerations During the Design of Poles.

According to Indian Standards 875-3 (1989), who

opined that the following characteristics/considerations should be taken into account when designing a pole: the length of the poles and their spacing. What will be the correct height of all poles? How far down will the pole need to penetrate the ground? The quality of the concrete mixture should also be considered. What will be the diameter of the pole? What type of reinforcement was needed to be used?

2.6 Factors to be Considered When Designing the Concrete Poles Against Wind

Indian Standards Code of Practice (1987) Illustrated that the following factors should also be put into consideration when designing reinforced concrete poles. Poles shall be designed so that the cracking strength of the pole exceeds 40 percent of the required ultimate strength; Poles shall be designed to withstand a one-point (tilting) pickup during erection; and Pole design shall include allowances for loads from handling, transportation, and erection without failure.

2.7 Failure of Reinforced Concrete Poles.

Indian Standards Code of Practice (1987) Explained that the reason for using reinforced concrete as a construction material is to take advantage of the best attributes of both concrete and steel. The most common loading condition for poles is the bending moment. When the bending moments are large enough, the concrete on the outside curvature of the pole will go into tension and perhaps crack; the steel resists the crack by resisting the applied stress. When very low overload factors are used (such as those familiar in the 1.0-1.1 range for high wind), the poles will crack under factored loads. According to Howard, W.M. (1987), "for a successful implementation, the design of concrete poles and making provision for testing of their strength will ensure an all-time reliable working system".

For an electric overhead system, the supports for the conductors and equipment must withstand the forces imposed on them. In contrast, the

conductors themselves must be sufficiently strong to support their own weight and the forces imposed on them. The forces acting on a pole stem from the vertical loading occasioned by the weight that has to be carried and from the horizontal loadings applied near the top of the pole. The conductors exert these latter forces as a result of uneven spans, or offsets and bends in the lines, and of the pressure of wind blowing against them.

In general, concrete poles are used in areas such as swamps and other persistently wet regions, where soils significantly shorten the lifespan of wood poles. Moreover, in such instances, the rate of decay may be erratic and uncertain, permitting unsafe conditions to arise and may not be discovered before accidents result. Concrete poles are also recommended in areas with chemical contamination and pollution, which may cause rapid deterioration of wood poles Kuebler, M.E. (2008). In agreement with Crosby, A. (2011), who stated that concrete poles are specified in special situations where poles of unusually high strength are required. Beyond the range of wooden poles where a guy cable or rope may be difficult or unobtainable, the stresses imposed on the concrete pole will be calculated as if it were a cantilever beam fixed at one end. These values will be used to select the poles.

3.0 RESEARCH METHODOLOGY

Data used were collected through observation/visitation, laboratory testing, and previous literature reviews.

3.1 Method of Data On Materials Collection

Materials used for the research include the following: The Cube

samples from each of the pole manufacturing factories visited, and reinforcement bars used by the companies.

3.2 Method of Data Analysis

Weighing and determining the crushing compressive strengths of concrete cubes and

testing the tensile strength of the reinforcement bars.: Observation/Visitation

To determine the real cause of reinforced concrete pole failures, visits were made within the State, especially in areas where critical failures have occurred, such as Geidam, Damaturu, and Potiskum, as well as at the manufacturing factories located in the study area.

4.0 VISITATION REPORTS/RESULTS FROM THE STUDY AREAS

The observation at Factory X revealed a marked difference in pole usage, with 30m concrete poles used for primary distribution and 26m poles for secondary distribution. The central discovery was the widespread structural degradation: many poles had failed or exhibited visible, wide cracks indicating imminent failure. The investigation attributed this poor performance to critical manufacturing defects, specifically substandard reinforcement bars that broke into pieces, a poor concrete mix that led to pole collapse, and overall poor artistry.

4.1 Method of production, Materials, and procedures

Factory X produced both 12m high-tension and 9 m low-tension poles using Dangote cement. Their process included tying Y10mm reinforcing bars and using a 1:2:4 concrete mix. A key operational detail is the curing process: poles were moved to the reservoir after only 24 hours using an electric chain machine and cured for 21 days. Before distribution, each pole underwent a hydraulic pressure bending strength test. The factory maintained a production rate of 10 poles daily with 12 employees in Factory Y.

4.2 Materials and procedures (round pole)

Reinforcement bars were bent to size (Y8mm) and placed into circular mould formwork.

Concrete mix ratio used: 2:4:6

Concrete placed in the mould was transferred to a spinning machine, which runs the entire mixture

to the required shape.

Concrete poles were steamed for twelve hours to make them very strong. After the steaming period, the poles were transferred to the reservoir using a hydraulic crane and remained there for 21 days to ensure proper curing.

A physical test was conducted using a cement hammer to tap the concrete and verify its readiness for use. They were also confirmed by the authorities or experts from the power company (YEDC) and the National Integrated Power Project (NIPP)

Pole type: round (i.e, circular high tension poles with 10.5m height). Cement type: Dangote

Factory Z.

4.3 Materials and Procedures;

Preparation for reinforcing bars and link fixing.

Reinforcement bars used were Y10mm and Y9mm for high tension poles, while R6mm bars were used for low tension poles.

Concrete mix ratio: 1:2:3 with enough vibration. After 24 hours, the poles were removed from the mould and, with the aid of a crane, dipped into a reservoir for 21 days. After 21 days, the poles turned white, and the water was drained out before the poles were dropped again. They were tested to confirm the concrete's strength.

Type of pole: four-sided poles at a height of 10m for high tension and 8.5m high for low tension.

While Dangote cements were used, the production methods in all three factories visited were similar, though with some differences, especially in the production of circular poles.

5.0 DISCUSSION AND RESULTS

The results of the analysis for the three manufacturing factories are tabulated in Table 4

5.1 Summary of Weights, Densities, and Compressive Strengths of the Above Sample

Reinforced Concrete Pole as Structural Support and Fault Minimization in Radial Electrical Distribution

System in Yobe State

Design Calculations. Thus;

Weights, densities, and compressive strength calculations

Factory X:

Sample 1:

$$\begin{aligned} \text{Volume} &= \text{length} \times \text{breath} \times \text{thickness} \\ &= 0.14 \times 0.07 \times 0.05 \\ &= 0.00042\text{m}^3 \\ \text{Area} &= \text{length} \times \text{breath} \\ &= 125\text{mm} \times 60\text{mm} \\ &= 7800\text{mm}^2 \end{aligned}$$

$$\begin{aligned} \text{Compressive strength} &= \frac{\text{Load applied}}{\text{Area}} \\ &= \frac{128 \times 1000}{7800} \\ &= 15.41\text{N/mm}^2 \end{aligned}$$

Sample 2:

$$\begin{aligned} \text{Area} &= \text{Length} \times \text{Breath} \\ &= 130\text{mm} \times 60\text{mm} \\ &= 7800\text{mm}^2 \end{aligned}$$

$$\begin{aligned} \text{Compress strength} &= \frac{\text{Load applied}}{\text{Area}} \\ &= \frac{115 \times 1000}{7800} \\ &= 14.74\text{N/mm}^2 \end{aligned}$$

Sample 3:

$$\begin{aligned} \text{Area} &= \text{Length} \times \text{Breath} \\ &= 130 \times 60 \\ &= 7800\text{mm}^2 \end{aligned}$$

$$\begin{aligned} \text{Compress strength} &= \frac{\text{load applied}}{\text{Area}} \\ &= \frac{175 \times 1000}{7800} \end{aligned}$$

$$= 22.43\text{N/m}^3$$

Factory Y;

Sample: 1

$$\begin{aligned} \text{Volume} &= \text{Length} \times \text{Breath} \times \text{Thickness} \\ &= 0.17 \times 0.15 \times 0.08 \\ &= 0.00204\text{m}^3 \end{aligned}$$

$$\begin{aligned} \text{Area} &= \text{Length} \times \text{Breath} \\ &= 170\text{mm} \times 150\text{mm} \\ &= 25500\text{mm}^2 \end{aligned}$$

$$\begin{aligned} \text{Compress strength} &= \frac{\text{Load applied}}{\text{Area}} \\ &= \frac{300 \times 1000}{25500} \\ &= 11.76\text{N/mm}^2 \end{aligned}$$

$$\begin{aligned} \text{Density} &= \frac{\text{mass}}{\text{Volume}} \\ &= \frac{6.142}{0.00204} \\ &= 3010.78\text{Kg/m}^3 \end{aligned}$$

Sample 2:

$$\begin{aligned} \text{Compress strength} &= \frac{\text{load applied}}{\text{Area}} \\ &= \frac{400 \times 1000}{25500} \\ &= 15.69\text{N/mm}^2 \end{aligned}$$

$$\begin{aligned} \text{Density} &= \frac{\text{Mass}}{\text{Volume}} \\ &= \frac{6.71}{0.00204} \\ &= 3289\text{Kg/m}^3 \end{aligned}$$

Table 3: Summary of weights, densities, and compressive strengths for factories X, Y, and Z

Factory X				Factory Y				Factor Z				
Sample	Weight	Lenght	Depth	Strenght	Weight	Lenght	Depth	Strength	Wieght	Lenght	Depth	Strengt
Summary	Kg	m	Kg/m ³	N/mm ²	Kg	m	Kg/m ³	N/mm ²	Kg	m	Kg/m ³	N/mm ²
1	5.001	128	11907	15.41	6.142	300	3010	11.76	4.230	140	3043	11.57
2	0.706	115	1680	14.74	6.71	400	3289	15.69	5.300	220	3818	18.18
3	5.750	175	13690	22.43	5.489	390	2690	14.89	5.006	200	3601	15.52
Total	11.44	418	27,277	52.37	18.34	1090	8989	42.74	15.36	640	10462	45.27
Average	3.82	139	9.0923	17.46	6.11	363	2996	14.24	5.25	213	3487	15.09

Source: Laboratory Result (2025)

$$= 5.009 / 0.00139$$

$$= 3818 \text{Kg/m}^3$$

Factory Strengths X: Approximately 18N/mm²,

Factory Y: 14N/mm² and Factory Z:

Approximately 15N/mm²

Sample: 3

$$\begin{aligned} \text{Compress strength} &= \frac{\text{load applied}}{\text{Area}} \\ &= \frac{390 \times 1000}{25500} \\ &= 15.29 \text{n/mm}^2 \end{aligned}$$

$$\begin{aligned} \text{Density Mass/Volume} \\ &= 5.489 / 0.00204 \\ &= 2690 \text{Kg/m}^3 \end{aligned}$$

Factory Z;

Sample 1:

$$\begin{aligned} \text{Volume} &= \text{length} \times \text{breadth} \times \text{thickness} \\ &= 0.11 \times 0.11 \times 0.115 \text{m}^3 \\ &= 0.00139 \text{m}^3 \end{aligned}$$

$$\begin{aligned} \text{Area} &= 110 \times 110 \text{mm}^2 \\ &= 12100 \text{mm}^2 \end{aligned}$$

$$\begin{aligned} \text{Compress strength} &= 140 \times 1000 / 12100 \\ &= 11.57 \text{N/mm}^2 \end{aligned}$$

$$\begin{aligned} \text{Density} &= \text{Mass/ Volume} \\ &= 5.300 / 0.00139 \\ &= 3818 \text{K/m}^3 \end{aligned}$$

Sample 2:

$$\begin{aligned} \text{Compress strength} &= \text{load applied/ Area} \\ &= 220 \times 1000 / 12100 \\ &= 18.18 \text{N/mm}^2 \end{aligned}$$

$$\text{Density} = \text{Mass/ Volume}$$

Sample 3:

$$\begin{aligned} \text{Compress strength} &= \text{load applied/ Area} \\ &= 200 \times 100 / 12100 \\ &= 15.52 \text{N/mm}^2 \end{aligned}$$

$$\begin{aligned} \text{Density} &= \text{Mass/Volume} \\ &= 5.006 / 0.00139 \\ &= 3601 \text{Kg/m}^3 \end{aligned}$$

5.2 Results

In accordance with the procedure in BS code 5328 part 4 and BS code 1881, which gave the minimum and maximum compressive strengths of a cube for 21 days at 15N/mm²- 35N/mm², while the minimum compressive strength at the age of 28 days was 41N/mm².

Therefore, factories X and Z met the minimum standard, while factory Y had compressive strength below it.

Using the universal testing machine, the tensile strength of the reinforcement bars (Y10mm) was 1199 MPa = 1199 × 10⁶ N/mm² = 1199 × 106N/mm²

6.0 CONCLUSION

The failure of electrical concrete poles is attributed to systemic technical and procedural failures. Primarily, the manufacturing industry neglects design specifications for structural elements, a clear breach of engineering best

Reinforced Concrete Pole as Structural Support and Fault Minimization in Radial Electrical Distribution

System in Yobe State

practices. Furthermore, on-site issues such as poor installation, shallow foundations, inadequate technical supervision, and poor craftsmanship all contributed to the poles' collapse under wind action. In a separate finding, laboratory results suggest that concrete strength could be improved by using Dangote cement, which showed superior binding and compressive strength properties over other tested cements.

7.0 RECOMMENDATIONS

These recommendations aim to reduce the recurrence of reinforced concrete pole failures nationwide by enforcing standards across all phases. Consultants and constructors must conduct comprehensive geotechnical investigations and tests before installation. Additionally, all poles must be installed to a minimum foundation depth of 1 meter, featuring a concrete base above ground. The minimum material specifications should be a 1:2:4 mix ratio, Grade 20 concrete, and Y8 or T10mm steel reinforcement. There needs to be proper technical supervision of all construction work and a thorough inspection of all installation materials (such as steel bars and guy ropes). Regulatory bodies—including NEMSA, the Standard Organization, COREN, and the Electricity Regulatory Commission—must step up their monitoring and control roles to ensure compliance with these standards.

REFERENCE

Ilochi E. E., et al (1994). Analysis and design of poles for rural electrification Network. NSE. Tech. Transmission; 28(4). Pp.28-32.

Mosely, H.M., et al, (1999). Reinforced Concrete Design, 5th Edition, Palgrave, New York, pp.3-11

British Standards Institution (1997).BS 8110: Part I Structural use of concrete. Code of Practice for Design and

Construction, British Standard

British Standard Institution (1970). Specification for concrete Poles for electrical transmission and Traction systems. British Standard Publication, London. Pp.5-8.

Levy, M, and Salvadori, M (2002). Why Buildings Fall: How Structures Fail. Norton-Library of Congress Visual sourcebooks in Architecture, Design, and Engineering. Publisher: W.W. Norton, pp.346, ISBN:09331152x97 803933.

Wearne, P. (1999). Investigation into Sudden collapse (An experimental and finite element: High wind and earthquake)". American Society of Civil Engineering.

Boal, G.A. (1981); Electrical power Distribution, pitman publication. London, UK.

Shehata, A.Y, etal, (2005). Finite Element in analysis and design. Vol. 41. Pp. 1413-1440, cited by Sciverse Scopus.

Australian Energy report (2025) Risk-Based Proactive Pole Replacement, RIT-D Report, p 9-16.

Johanneson P, etal (2022) Mechanical Reliability Analysis of Flexible Power Cables for Marine Energy, Journal of Marine Science and Engineering. Vol . 10 Issue 716 pp.1-19.

Shalaby, A.M (2011). Analysis and deflection of concrete poles. PCI Journal, Volume 57, N0.2, Spring 2011, pp.55-77.

Niemann, H.J. (2004). The European Wind Loading Code: Break ground and regulations. American Society of Civil Engineers Structure Congress 2004.

Standard Guide for Specification PIC (2008). Design and verification of concrete use. PIC Journal. Vol . 28, No.3.

Reinforced Concrete Pole as Structural Support and Fault Minimization in Radial Electrical Distribution System in Yobe State

- Kalk, E, and Lafer, D (2004). Sesmic-based Strengthening of steel and RC telecommunication poles based on fem analysis. Eng. Structures 26(14) 2010-211.Doi:1016/j. engstruct 2004.07.006 pp.2101-2111
- Materials Specifications for steel poles and base mounting (2012). TS. 805 hHPS://www1.toronto.ca/WPS/Portal/Content only/Vgnextoid.....Vgnext Channel Jan.2012, TS805.200.
- David Corractine, et al, (2008). Residential Deck Ledger correction, testing, and design. Published by Structure Magazine from lessons Learned, Issues and Solutions encountered by practicing structural engineers.
- Guyana (2012). Earth charges and poles shift by the stab-rock staff. 25th Editorial. World Press.com.
- Guidelines for Design (2006). Guide for design maintenance of overhead Distribution and Transmission. <https://infostore-saiglobal-com/store/preview Doc as px? Saleitem 10=745617>.
- Jim Brooks (2010). Network lines standards magazine on Concreting. 23 August, (page 1 of 20).
- Indian Standards 875-3 (1989). Code of practice for design loads (other than earthquake) for buildings and structures. Part 3: Wind loads (CED37: structural safety).
- Howard, W.M. (1987). Concrete Pole Design and Use Guide Line. A SCE Publication. hHps://www.seribd.com/doi/54615986/concrete pole+8. Accessed 24/8/2017.
- Indian Standards 875-3 (1989). Code of practice for design loads (other than earthquake) for buildings and structures. Part 3: Wind loads (CED37: structural safety).
- Indian Standards Code of Practice (1987). For Design loads (other than Earthquake) for Buildings and Structures: Second Revision, Sixth Reprinted Nov. 1998.
- Howard, W.M. (1987). Concrete Pole Design and Use Guide Line. A SCE Publication. hHps://www.seribd.com/doi/54615986/concrete pole+8. Accessed 24/8/2017.
- Kuebler, M.E. (2008). The design and response of concrete poles. (ASCE/PCI Joint report) Canada.
- Crosby, A. (2011). Current Practice in utility Distribution poles and high poles. Structure Magazine, 5th May 2011. www.Kornegayengineering.com/wp-content/uploads 2011. Structural utility distribution, Light poles-white papers-acrosby.pdf.