Investigation into the Causes of Electric Transmission Concrete Pole Failures

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Investigation into the Causes of Electric Transmission Concrete Pole Failures

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Abstract

The major causes of electric concrete pole failures has been highlighted in this paper and possible solutions suggested. The technique involves an on-site assessment and analysis of some factors that influence the design and manufacture of concrete pole commonly used for electrification purpose. Some major manufacturers in Niger State, Kwara State and Federal Capital Territory, Abuja, Nigeria were visited and interview conducted on their method of design and manufacture of electric transmission concrete pole. Site study of some major high-tension and low-tension electrification work was also carried out. Based on observation made anomalies in concrete pole manufacture were pointed out and solution proffered. Finally concrete pole suitable for electrification purpose was designed and constructed. A rig was constructed to test the strength of the pole, thereby determining their suitability for electrification work.

Keywords

Concrete poles, Transmission failures

Introduction

In recent time the Federal Government of Nigeria has mapped out a number of programs aimed at improving the living conditions of some rural communities in this country. Efforts are being made to provide necessary facilities and amenities in the rural places to curb the mad rush to urban areas.

Among such development efforts are the National Local Government Headquarters (LGHQ) electrification and the entire rural electrification programme. This programme is also on the priority list of this present regime. For a successful implementation of this well-intentioned programme, the design Headquarters (LGHA) electrification and the entire rural electrification programme [1]. This programme is also on the priority list of this present regime. For a successful implementation the design of concrete pole and making provision for testing of its strength will ensure an all-time reliable working system. For an electric overhead system, the supports for the conductors and equipments must withstand the forces imposed on them, while 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 it has to carry and from the horizontal loadings applied near the top of the pole. These later are exerted by the conductors as a result of uneven spans, of offsets and bends in the lines, and of the pressure of wind blowing against them.

This paper contributes to knowledge by giving some recommendations on how to solve the problems associated with electric transmission concrete poles failure. This advice if implemented by the appropriate authority will go a long way in alleviating these problems.

Theory

In general, concrete poles are used in those areas, such as swampy and persistently wet areas where the soils greatly shorten the life expectancy of wood poles. Moreover, in such instance the rate of decay may be as erratic and uncertain as to permit unsafe condition to arise and may not be discovered before accidents result. Concrete poles are also specified in areas of chemical contamination and pollution that may cause rapid deterioration in case of wood poles [2].

Concrete poles are specified in special situations where poles of unusually high strength are required, beyond the range of wood poles, and where guying may be difficult or unobtainable. Stresses imposed on concrete pole are calculated, as if they were cantilever beam fixed at one end. These values, with proper factors of safety applied, are used in the selection of the pole. The forces acting on a pole are from:

- The vertical loading (comprising of Dead weight of conductors, cross arms, insulators an associated hardware).
- The Horizontal loading (due to wind pressure on conductors and pole).

The requirements of horizontal loading usually overshadowed that of the vertical to the extent that it may not be given further attention. For the horizontal loading, the pole can be considered as a cantilever beam anchored at one end (butt end) with a load applied (600mm) at the other top end. The bending moment produces stresses in the concrete with the maximum fibre stress occurring at the edge of the cross section farthest from the neutral axis; the stresses are compressive on the side on which the load is pulling and tensile on the opposite side BS607 Part2 gives the minimum ultimate transverse load for different class of poles as shown in Table 1 (adapted from [3]).

Table 1. Minimum Ultimate Transverse Loads (MUTLs)

Class of Pole	1	2	3	4	5	6
MUTL at 0.6m from top (KN)	2.8	3.9	5.6	7.8	11.1	15.6

Methodology

On-Site Study of Some High-Tension and Low-Tension Electrification Work

There has been in the recent past improvement in the provision of electricity for the rural communities in this country. This emanates, from the Federal Government of Nigeria, National Local Government Headquarters (LGHQ) electrification and the entire rural electrification programme. Among such development efforts in Niger - State is the Doko - Basa rural electrification project, Daya -Gwada rural electrification, and Gidan - Mangoro - Sabon Daga rural electrification project. Some other developmental work executed by the Niger State Government on it’s own includes Takumpara- Takuti rural electrification project and Enagi - Kudu High - Tension electrification work.

Project site for electrification work were visited. In the course of the visit, it was found that 10.5m long concrete poles were used for the 11kv primary distribution line. The 8.5m long concrete poles were used for the Secondary distribution line. Some poles were found to have failed and some shows sign of failure as a result of wide visible cracks observed on then. The failures of concrete poles while electrification works were still under construction were mainly noticed on the Gidan Mangoro - Sabo Daga rural electrification work and the Enagi - Kudu High Tension electrification projects.

An Overview of Some Concrete Pole Manufacturing Company

Research revealed that there are few number of concrete pole manufacturers in existence. In Minna, and possibly in the whole of Niger State the only concrete Pole producer is "GB and Sons Enterprises Nig. Manufacturer of Electric Concrete Pole", along Minna - Bida, Minna, Niger State. In Ilorin, we have Savannah Precast Concrete and Terrazzo Industries Ltd; also engaged in the manufacturing of concrete poles, at Dei-dei, near Abuja, we have Powerline Electric Concrete Pole Manufacturing Company. Prefab Nig. Ltd are based at Sharada Industrial Estate, Kano.

The method of concrete pole production is similar in all the sites visited. The workers are usually divided into three main groups, those who arrange the formwork and do the casting of the pole. The third set of workers is concerned about the curing of the pole, which is a very vital aspect of pole production. The coarse aggregate used by Powerline Concrete Pole Company consist of mixture of ½" and ¾" while GB and Sons use only ½" aggregate for production. At Powerline Electric Concrete Pole Company, the method of Curing involves wrapping the Concrete pole with sacks and placing it in water for 21days. At GB and Sons, the curing process involve, wrapping the pole with sacks and applying water at interval of time, depending on weather situation. The pattern of production at Savannah Precast Company, is in the same manner with that of Powerline. By visual inspection, Savannah Precast Company seems to produce better product, followed by Powerline.

One major problem, that is peculiar to all the concrete pole manufacturing company, is lack of rig for testing their final product. When each of this company were asked about the requirement of the code, that concrete pole must be tested in batches by a third party before being sold, they seem to be ignorant of these very important regulation, all they say is that, they normally test their concrete cube samples. They however, show interest in getting their product tested according to the code requirement whenever possible.

Results

Making of Concrete Pole

Based on the outcome of design, two concrete pole sample, identical in shape were produced. The formworks was made of timber with nylon linen to allow for workability and compactibility of concrete mix 14mm single size chippings was used as coarse aggregate and sharp sand as fine aggregate with cement reacting with water acting as binder. 1:2:4 (cement, sand, granite) mixing ratio was used. Pole 1 (P1) was vibrated using 50mmϕ poker, while pole 2 (P2) was not. The reason for this is to allow for comparison of strength between vibrated and a non vibrated concrete pole. Provisions were made for through hole spacing and sizes based on specification [4]. The pole was cured by placing sand on it, and applying water daily for 14days. The fresh concrete was adequately protected from hot sun and rapid loss of mixture.

Concrete Testing

Concrete cube samples for strength tests of concrete were taken 3cube samples for each pole cast were taken, in accordance with British Standard Specification, structural use of concrete 150mm × 150mm standard cubes were used to insure the required strength of products. Each strength tests were performed 28 days after casting. The strength levels of the concrete were considered satisfactory, since the average of test result exceed the required strength and no individual strength test result falls below the required strength by 3.52 N/mm^2 [5].

Bending Test

Bending strength tests were performed for the concrete poles constructed, in order to assure that the poles meet the minimum structural strength requirement in accordance with specifications. This was done by constructing concrete pole testing rig. The poles were tested in horizontal position. This was done by holding the pole rigidly at the butt end in accordance with the supported length specified in the code (Table 2, [3]).

Table 2. Pole supported length

Length of pole (m)	8.0 - 9.2	9.8 - 12.2	13.4 - 15.8
Supported length (m)	1.5	1.8	2.1

In this case, 1.5 m was used as the supported length, since length of pole tested is 8.5m. Suitable support was provided for the pole in the horizontal position, to minimize the bending moment induced by the weight of the pole. The instrument devised for measuring the force, comprises of 5 ton hydraulic jack with a pressure gauge connected to it. The pressure gauge has been calibrated to read force. Test load were applied at 0.6 m from the top of the pole in increments of 0.5 KN and measurements of deflection taken after each load increment.

Results of the bending test shows that Pole 1 (vibrated concrete - table 3, then figure 1) fails after total deflection of 1504 mm and 11.52 KN. Pole 2 (un-vibrated concrete - table 4, then figure 2) fails after total deflection of 772 mm and 9.14 KN.

Table 3. Experimental readings from strength testing of pole (P1)

Pressure (MPa)	Load (KN)	Deflection (mm)	Remarks
2.0	0	0	No visible hair cracks
2.5	0.59	1	“
3.0	1.18	2	“
3.5	1.77	4	Appearance of hair crack on 5 spots (4.94, 5.5, 6.1, 6.5, 6.7 m from tip)
4.5	2.95	21	“
5.0	3.54	69	Further appearance of cracks (at 3.27, 3.43, 3.54, 4.07, 4.94, 5.3, 5.5m from tip)
5.5	4.13	129	Cracks widens
6.0	4.75	224	“
7.0	5.94	399	“
8.0	7.13	594	“
9.0	8.31	817	“
10.0	9.50	1074	“
11.0	10.69	1352	5.5mm wide crack at 3.54m from tip
11.7	11.52	1504	Failure occur at 3.54m from tip

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Table 4. Experimental Readings from strength testing of pole (P2)

Pressure (MPa)	Load (KN)	Deflection (mm)	Remarks
2.0	0	0	No visible hair cracks.
2.5	0.59	1	"
3.0	1.18	2	"
3.5	1.77	12	Appearance of hair crack at 3 spots (4.16, 4.28, 4.53 m from tip)
4.0	2.36	24	"
4.5	2.95	41	Appearance of visible cracks at 12 locations (1.72, 2.17, 2.51, 3.79, 3.97, 4.16, 4.28, 4.53, 4.65, 5.38, 6.8 and 6.97m from tip of pole)
5.0	3.54	69	"
5.5	4.13	129	Cracks widen to about 0.5mm (at 4.28, 4.53, 4.65 m)
6.0	4.75	142	Cracks widens on all sports
6.5	5.31	198	"
7.0	5.90	263	"
7.5	6.49	338	"
8.0	7.08	425	"
8.5	7.67	517	"
9.0	8.26	624	"
9.5	8.85	739	5mm wide crack run through the section of the pole at 4.35mm from tip
9.7	9.14	772	Total failure (fracture) of pole occurs at 4.35m from tip at the tension side of the pole

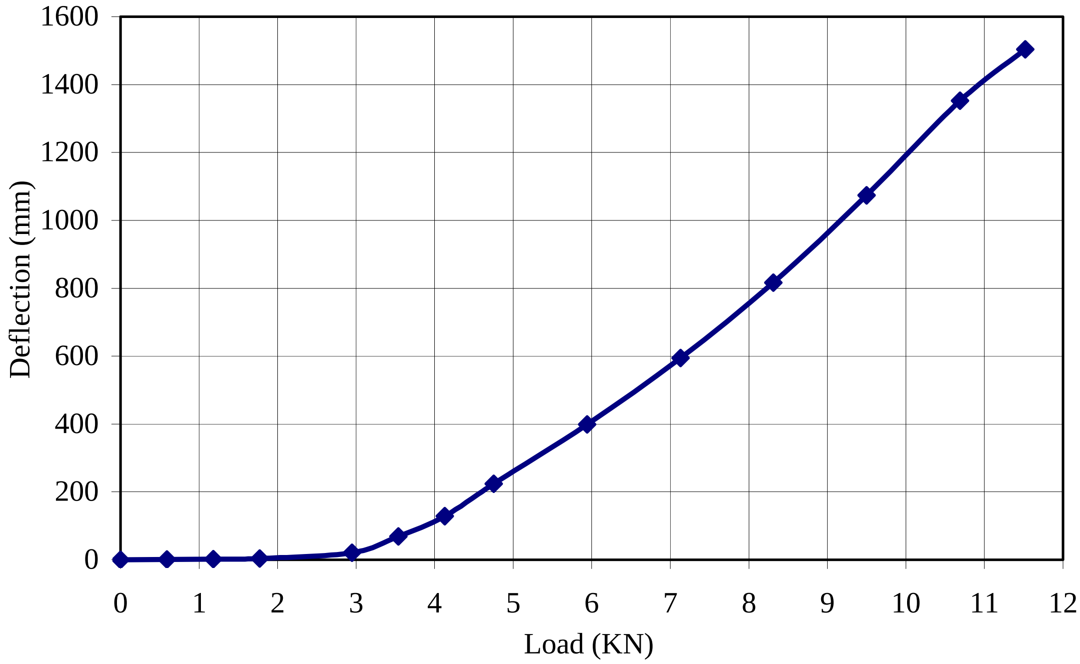

Figure 1. Load Vs Deflection Curve Pole1 (P1)

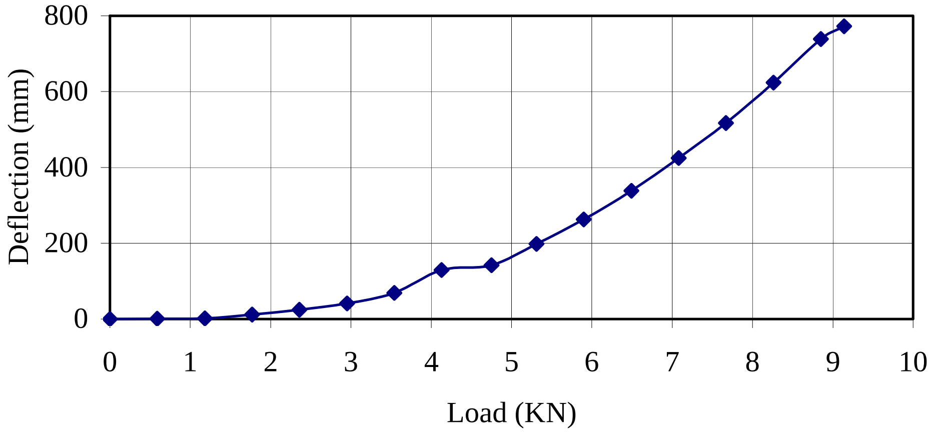

Figure 2. Load vs. Deflection Curve Pole 2 (P2)

Conclusions

On-site investigation of some electric transmission concrete pole manufacturing company was carried out. Some overhead electrification works were also studied. Major causes which are responsible for production of low strength concrete poles by manufacturers have been pointed out; better production methods was suggested, constructed and used successfully.

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