ISSN: 2278-4632
Vol-10 Issue-5 No. 10 May 2020

Design of High Strength Stocky Electric Pole with Prestressed Fly-Ash Concrete

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Abstract:

This paper presents the study of pre-stressed concrete electric poles. The aim of this paper is to design the pre-stressed concrete pole by reducing concrete partially from a typical model of concrete pole. The fly-ash concrete is the promising alternative material for the cement concrete. The studies of fly-ash concrete on its properties have also shown its suitability for various construction applications. This led researchers to consider the use of fly ash concrete in precast concrete and prestressed concrete components such as utility poles.The determined mechanical properties of fly-ash concrete were also compatible with the cement concrete. This work includes the design of Economic Pre-stressed concrete electric poles. The drawbacks related to the application of Reinforced Concrete poles include a high self-weight and susceptibility to damage. Self-weight might be reduced by prestressing the reinforcement and by adding fly ash.

Keywords

Pre-Stressing, Poles, Fly-ash, Precast, Economic, Vulnerability, Reinforcement

Introduction

First designed and constructed by Freyssinet in the middle 1930s, prestressed concrete poles are used today worldwide for telephone poles, telegraph poles, and electric poles, electric power lines, antenna masts, and overhead power lines for electric trains. In parts because they can be factory produced, prestressed concrete poles are now used widely throughout the world including India. These poles offer several advantages: Pre-stressed concrete poles are lighter in weight and stronger in strength, and these require less reinforcing steel to strengthen. The concrete is generally good in compression, so cracking is unlikely except from loose handling of members, and the concrete used is of higher strength so it can perform stable pre-stressing operation.

An another reduction in weight can be adopted by removing concrete partially from rectangular or trapezoidal model of electric pole at various length of a pole. The shape of reduction in test is decided to rectangular and circular with equal area. Use of fly-ash replaces a portion the standard concrete material like cement. According to the standard addition amount of fly ash 20%, the water demand is reduced by 10%. Fly ash reduces the heat of hydration, increases the ultimate strength, reduces the permeability, and improves the durability of the structure.

Due to the special manufacturing process, in which the poles are cast at high manufacturing rates, these have a clear surface that is denser and less permeable. This lower permeability in combination with the absence of cracks prevents corrosion effect of reinforcement or pre-stressing wires. The pre-stressed concrete can be made stronger and more slender.

Pre-stressed concrete poles can be made in many shapes. Poles up to length of 15 m long with square or rectangular solid cross sections are easy to manufacture, occupies much lesser space. Pre-stressed concrete is the most recent and important major form of construction introduced in the structural and concrete engineering. The pre-stressing and pre-casting of concrete are correlated features of the modern building industry & market. By common application of innovative design and quality control major, they have increasing impact on construction and architectural procedures, Pre-stressing of concrete is the application of compressive force to concrete member and may be achieved by either pre-tensioning high tensile steel wires before the concrete has set or by the post tensioning method after the concrete has set. Pre-stressed concrete poles were from the first application of pre-stressing technique that French pre-stressing pioneer Eugene Freyssinet developed in the year 1930's. However, the increase in cost of wood and the other issues for environmental associated with the preservation of trees have resulted in a decreased use of wood and increased use of concrete poles. Therefore, the potential for a much greater use of precast pre-stressed concrete poles throughout the world is more favorable and promising.

Scope

This work includes the design of pre-stressed fly-ash concrete electric pole of different shape reduction & compares their relative strengths vis-a-vis each other. Concrete grades were also varied. With a high requirement of electric power manufacturing of economic electric pole is needed. The onus was on economy & durability.

ISSN: 2278-4632
Vol-10 Issue-5 No. 10 May 2020

Literature

The poles should be designed so that their transverse strength is sufficient to withstand the loads caused mainly by the wind on the wires and poles, and then multiply by the load factor.
Load factor is the ratio of ultimate transverse load to transverse load at first crack.
The strength in the direction of line should not be less than a quarter of the strength required in the transverse direction.
Poles made of ordinary Portland cement should be tested after 28 days, and poles made of fly ash concrete can be tested after 14 days of manufacture, because fly ash particles are smaller than cement and will reduce the hydration heat reaction. The electric pole can be tested in horizontal or vertical position. If the observed limit lateral load is less than the design limit lateral load, the rod is considered to have failed the test.

Methodology

The pole appears as a cantilever structure, so it should be analyzed and constructed as a member to withstand wind and bending stresses [i]. The bending moment caused by wind load is greater than the shearing force, which is why it causes bending stress. Prestressed concrete electric poles are easily stretched. Unless the structure is heavy, axial loads are usually ignored. In the design, the stress caused by transportation, handling and installation should be considered. The electric poles must withstand equal bending moments in opposite directions, which is why this requires uniform prestressing, so the magnitude of the prestressing force can only be half the strength normally used to bend in one direction.

Experimental Programme

The experiments are carried out to determine the properties of prestressed concrete electric poles.

Workability

The spherical particles of fly ash play the role of a tiny ball bearing in the concrete mixture, and therefore have a lubricating effect. This same effect also improves the pumping capacity of concrete by reducing frictional losses during pumping and the ability to complete during leveling. Replacing cement with fly ash can reduce water demand for a given slump. When in the total amount of cement concrete using fly ash is about 20%, the water demand will be reduced by about 10% [iii]

Table 1: Properties of Aggregate used

Property	Value
Specific Gravity	CA 2.79 FA 2.76
Crushing Value	20%
Impact Value	15%
Attrition Value	21%
Abrasion Value	24%
Shape Tests (EI+FI)	13%

Compressive Strength Test

Concrete mixes can be designed to provide a wide range of mechanical and durability properties to meet structural design requirements. The compressive strength of concrete is the performance property and most commonly used by engineers when designing structures. Compressive strength is measured by breaking a cylindrical or cubical concrete specimen in a compression tester. The compressive strength is calculated by dividing the breaking load by the cross-sectional area of the resisting load and reporting it in megapascals (MPa).

Pole preparation

Pre-stressed fly ash concrete utility poles are basically made of concrete. Compared with traditional steel poles, it is unavoidably lower in cost and higher in maintenance costs. There are two types of very low and high tensile wires depending on their end use. The latter is mainly used for power transmission. High tension steel wire is inserted into a pre-designed mold and stretched to achieve a certain tension. The galvanized wire is fixed in the mold for grounding. Then, the concrete is compacted by vibration to make a high-strength fly ash concrete rod. After 72 hours, the tension was released and demolding was completed. Place the poles under water for testing for 14 to 28 days.

Result and Discussion

Compressive strength was conducted in between load and displacement. Two samples of prestress fly-ash concrete electric pole with reduced ratio were made on the basis of higher compressive strength.

Fly-ash at various proportions of 0%, 10%, 20%, and 30% showed different physical, chemical and mechanical properties. The table gives data about various compressive strengths at 7 and 24 days

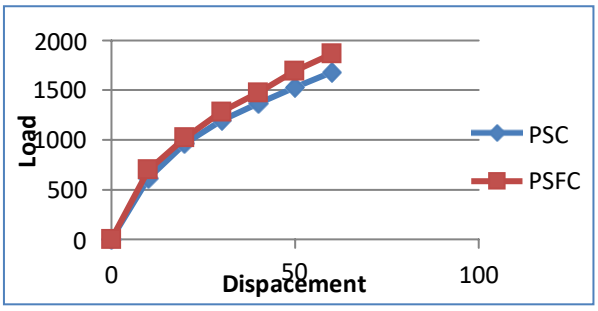
Table 2: Result of test at sequential proportions

Sample(% of fly-ash)	Compressive Strength at 7 days (N/mm^2)	Compressive Strength at 28 days(N/mm^2)
S1 (0%)	29.79	39.73
S2 (10%)	30.65	41.35
S3 (20%)	33.89	43.56
S4 (30%)	32.56	43.34

ISSN: 2278-4632
Vol-10 Issue-5 No. 10 May 2020

From the table 2 compressive strength of samples is compared, test result shows more than 20% fly-ash in concrete proportionate inversely to compressive strength of concrete.

Figure 1: Load Displacement result for PSFC poles and PSC poles



Conclusion

With reference to the above discussion, the following conclusions are made:

i. Compared with traditional concrete mixtures, the designed fly ash concrete is feasible and shows higher mechanical properties.
ii. Addition of fly-ash in cement concrete from 0% to 30% results a simple increase in strength till 20% addition is 43.56 N/mm^2, more than it strength decreases slightly is 43.34 N/mm^2 at 30%.
iii. As shown in figure 1 results are easily comparable and PSFC is slightly better than PSC poles for a displacement 60 mm applied load is 1865 in PSFC poles and 1680 in PSC pole.
iv. Compared with simple concrete pole specimens, prestressed fly ash concrete poles have higher lateral strength and lower deflection. The test of prestressed fly ash concrete utility poles is earlier than that of simple utility poles.
v. Therefore, prestressed fly ash concrete utility poles can become more time-saving, economical, and safe, so they can be effectively replaced with simple utility poles.

Acknowledgements

i. We sincerely thank Er. Narendra Bhadana for encouragement and full support help and patience in our project of prestressed fly-ash concrete electric pole manufacturing.
ii. With immense pleasure with we are submitting the research article on “Design of High Strength and Low cost Electric Pole by Partially Reduced Concrete with Prestressed Fly-Ash Concrete”

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