Research on poles selection and poles reuse of distribution line

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Abstract: Based on the model selection of distribution line poles and towers, this paper presents the application scheme of high strength concrete poles in distribution lines. At the same time, it studies the reuse of dismantled old concrete poles and puts forward a graded utilization programme. Research achievements can guide the model selection and reuse of distribution line poles so as to help power grid enterprise to improve their quality and enhance their efficiency.

1.Introduction
In recent years, with the implementation of upgrading of urban and rural power grids and development of power network, large diameter of distribution line is setting up to form multi-loop system, meanwhile, the structure and load of poles and towers are requiring more, therefore, traditional circular reinforced concrete poles cannot meet the requirements of loading capacity and transportation and installation of some distribution lines. Consequently, research on poles selection of distribution line is becoming necessary. During the upgrade of distribution line, many concrete poles are replaced, but some disused ones fail to give full play to their lifetime value and have the using value of original products. Waste and old electric power materials are an important renewable resource for enterprises. Deepening the comprehensive utilization and environmental protection of waste electric power resources and standardizing the recycling and disposal methods and behaviors are of great significance for power grid enterprises to implement green production, tap potential and increase efficiency, put social responsibility of enterprises into practise, and strengthen the administration of enterprises in accordance with the law.

2.Poles selection scheme of distribution line

2.1 Current status of poles selection
At the present stage, poles and towers are mainly selected according to typical design requirements of distribution network project of State Grid Corporation of China.

2.1.1 10KV single-loop concrete poles

| Working condition | Straight line | Resistance to tension |
|-------------------|---------------|-----------------------|
| Single-loop       | 12m (M strength grade) non-prestressed | 12m (M strength grade) non-prestressed |
Single-loop
Without low voltage
10m (1 strength grade) non-prestressed
12m (M strength) non-prestressed
Cross lines
15m (M strength grade) non-prestressed
Refers to double-loop
Unable to erect pulling line
at corner below 30°
12m (0 and T strength grade) non-prestressed
Unable to erect pulling line
at corner over 30°
Steel poles, narrow base tower

2.1.2 10KV double-loop concrete poles

Table 2 recommendation form for 10kv double-loop concrete poles

| Working condition                  | Straight line                | Resistance to tension |
|------------------------------------|------------------------------|-----------------------|
| Double-loop                        | 15m (M strength grade) non-prestressed | -                     |
| Corners no more than 45°           | -                            | 15m (M strength grade) non-prestressed |
| Corners more 45°                   | -                            | 15m (M strength grade) non-prestressed |
| Unable to erect pulling line at corner below 12° | -                            | 12m (T strength grade) non-prestressed |
| Unable to erect pulling line at corner over 12° | -                            | Steel poles, narrow base tower |

10kV triple-loop and quadruple-loop concrete poles. For straight line poles, 18m (N strength grade) non-prestressed poles will be applied with steel tube poles at corner.

For 10KV cables, single concrete poles will be used in large span distance no more than 120m, and portal framed double concrete poles will be used in large span.

Power line at river and suburban area: some 10KV power lines are required to cross the river, so iron towers and steel tube poles are frequently replaced 10KV concrete poles aiming to decrease the quantity of poles and increase the space of span distance of poles.

2.2 Application of high strength concrete poles in distribution line

2.2.1 Application scenarios of high strength concrete poles in distribution line

Base on the selection principle of 10kV distribution line poles and towers, ordinary concrete poles are used for straight lines, and concrete poles with pulling line can be used for single-loop and double-loop power lines with small angle. However, concrete poles with pulling line cover a large area, and its land requisition coordination is very difficult, meanwhile, poles are very easy to be pushed over and fall down once pulling wire is destroyed. Therefore, concrete poles with pulling wire are avoid to be applied in urban programme of 10KV cable. Steel tube poles and iron towers shall be applied in such locations as single-loop corner more than 30°, double-loop corner more than 12°, quadruple-loop corner and large span distance area, where pulling wire cannot be installed.

The steel tube pole has stable structure and mature technology, and occupies a smaller area than the ordinary concrete pole, which can save the corridor and land resources of power line. However, it costs high and must be galvanized to achieve the purpose of corrosion resistant in the production process, which may contaminate the environment.

Under the general principle of “safety, application, economy and environmental protection”, high strength concrete poles will be applied to replace original steel tube poles. High strength concrete poles will be applied in such locations as single-loop corner more than 30°, double-loop corner more than 12°, quadruple-loop corner and large span distance area, where pulling wire cannot be installed.
2.2.2 Characteristic of high strength concrete poles
With the characteristics of short production cycle and large loading capacity, single high strength concrete pole can replace the poles with pulling wire at locations where pulling wire is unable to be installed due to local narrow corridor. And its span distance can reach to 300-400m meeting the requirement of large span projects.

Working life of high strength concrete poles can reach to 50 years with the advantages of simple construction, high strength concrete, high strength and light weight, rapid and convenient installation and low cost of maintenance.

2.3 Technological and economic analysis of high strength concrete pole and steel tube pole
Designing conditions: maximum wind speed: 25m/s; designing icing thickness: 5mm; cable: JKLYJ-240, highest temperature: +40℃; lowest temperature: -20℃; biggest icing thickness: 10mm. Span distance of double-loop pole: 60m; span distance of quadruple-loop pole: 50m. All applied poles will be without pulling wire. Single-loop pole will be upward lined up and double-loop pole will be drum lined up.

Table 3 technological and economic analysis of high strength concrete pole and steel tube pole

| Type of pole          | Height of the pole (m) | Steel tube pole type | Cost (¥) | high strength concrete pole type | Cost (¥) |
|----------------------|------------------------|----------------------|----------|----------------------------------|----------|
|                      |                        |                      |          |                                  |          |
| Double-loop corner 0-30° | 15 GN27-13              | 22525                | 310-15   | 10000                            |          |
|                      | 18 GN31-16              | 23375                | 310-18   | 11000                            |          |
| Double-loop corner 0-60° | 15 GN31-13              | 33150                | 390-15   | 21000                            |          |
|                      | 18 GN35-16              | 34000                | 390-18   | 23800                            |          |
| Double-loop corner 0-90° | 15 GN35-13              | 34850                | 430-15   | 25800                            |          |
|                      | 18 GN39-16              | 35750                | 430-18   | 27800                            |          |
| Triple-loop corner 0-30° | 15 GN31-13              | 27200                | 430-15   | 25800                            |          |
|                      | 18 GN31-16              | 29750                | 430-18   | 27800                            |          |
Through comparison and analysis, high strength concrete pole can greatly reduce the construction cost of power grid. Under same using condition, high strength concrete poles can save about 30% of the cost compared with steel tube poles, showing obvious economic advantage. In the meantime, steel tube pole must be galvanized to meet the requirement of corrosion resistant, which may seriously contaminate the environment. While high strength concrete pole, replacing steel tube pole, needn’t to be galvanized which conforms to the construction concept of “economy, green, low-carbon, environmental protection”, and has obvious social benefits in improving environmental protection.

3. Pole reuse scheme

3.1. Current disposing status of dismantled old concrete poles
A large quantity of concrete poles will be decommissioned in the course of line reconstruction. For concrete poles with short using time and in good condition, they will be returned to the warehouse and then be reused in line upgrading projects. For concrete poles with long using time, they are mainly auctioned as waste materials or buried on site.

3.2. Reuse scheme of dismantled old concrete poles
A large quantity of concrete poles will be dismantled during the upgrade of distribution line. In order to give full play to their residual value of the dismantled old concrete poles, it is necessary to make a green reuse plan according to their service conditions.

The dismantled old concrete poles can be divided into three kinds according to their use value: first, poles, remaining use value of the original product and not reaching to their working lives, can be reused; second, poles, remaining part of their use value and lost part of their use value, can be overall used for other purpose; third, poles, entirely lost their use value, can be used as a renewable resource.

3.2.1. Concrete poles returned to warehouse for reuse
Dismantled old concrete poles with short using time and in good condition can be returned to warehouse and later applied in the line transfer or other reconstruction projects to give play to their remaining use value.

3.2.2. Reuse of overall concrete poles
Concrete poles with cracks that cannot be directly put into application can be used in temporary construction of power project after being tested, or directly used in temporary cable project or supporting project of deep foundation pit as cable protection pipe.

3.2.3. Dismantle and reuse of concrete poles
The dismantled old concrete poles, completely lost their use value, can be disposed as waste concrete. At present, it can be divided into the following three methods: low-level utilization: general back-filling; intermediate utilization: basis material for building or road; advance utilization: being processed into aggregate with particle size smaller than 40mm for concrete production, i.e., recycled aggregate concrete.

Concrete poles, completely lost their use value, can be made full use by the mean of “collectivization, factorization, recycling”, thus solving the problem of waste concrete pole to be green reused.

Waste concrete poles will be dismantled first and then uniformly transported to qualified enterprise for crushing and separation. After separation, rebar will be recycled directly, and cement residue is separated into coarse aggregate and fine aggregate. The coarse aggregate will be made into concrete by adding nanometre polymer composite liquid of special material and applied in beam and load-bearing wall.
Fine aggregate can be used in the production of electric prefabricated products on the principles of modular assembly, simplified form, lightweight of single one, convenient construction, such as prefabricated cable duct bank, precast walls of transformer substation, precast firewalls and so on.

Figure 2 prefabricated cable duct bank

Waste poles, being made into new construction material, can be made into membranes plate and partition plate applying in urban construction, or made into roadbed stabilized layers laying on urban roads, so as to make their best use and realize the goal of green reuse of dismantling old concrete poles.

Figure 3 precast walls and firewalls of transformer substation

By measurement and calculation, 1 ton residue can be recycled from 1 concrete pole of 15m, and be able to made into new building material after adding cement. If the renewable product is 300 yuan per ton, disposal of 1000 concrete poles every year will create renewable products valued about 300 thousand yuan.

Calculated by disposing 1000 concrete poles, about 700m³ aggregate resources will be wasted according to the traditional backfill after crushing and separation. However, after the green reuse treatment, not only aggregate, rebars and other resources will be saved, but also dust pollution is reduced.

4. Conclusions
In same conditions, high strength concrete poles can save about 30% of cost compared with steel tube poles, showing obvious economic advantage. At the same time, there are obvious social benefits in improving environmental protection. Therefore, it is recommended to apply high strength concrete pole to replace corner steel tube pole or increase the pan distance in distribution line so as to lower the project investment.

The recycling mechanism of concrete poles needs to be perfected. It is necessary to establish the technical qualification standard of re-usability for the concrete poles that can be reused, and the feasibility of reuse should be comprehensively considered according to the service time,
service life, current situation and reuse cost.

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