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APPLICATION OF HOLLOW STEEL POLES FOR DISTRIBUTION OVERHEAD LINES

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INTRODUCTION

The Power Utility of Serbia exclusively recommends the application of concrete poles for distribution overhead lines, according to the Technical recommendation of Serbia No.10.

Concrete poles are used up to the height of 21 m and rated loading at the super structure up to 2000 daN . The lengths of poles are limited due to the limited lengths of the existing moulds and the production process. The poles exhibit great reliability, presuming the correct dimensioning and quality of production, either produced as pre stressed or as classically reinforced. Their shortage is a heavy weight that causes difficulties upon the transport and the installation rising the price of the overhead line erection.

In the case when greater length of the pole is needed there is a solution in making the rising foundation that can rise the pole up to 1 m, with considerable expenses.

In the case when greater loading of top hamper is needed the combination of poles with two or three concrete tower bodies is used which increases the number of concrete cross arm types and considerably increase the price of the overhead line. Even with the installation of poles consisting of two or three concrete pole bodies, maximum loading is increased to 6 000 daN that is 8 000 daN . However, the poles with two or three concrete tower bodies occupy greater area surface as well as volume, not to mention visual pollution.

The limited possibilities of concrete poles can be overcome by the application of hollow steel poles.

Hollow steel poles were installed for the first time on places where the installation of concrete poles was not possible. Taking into account the advantages such as transportation and pole erection, these have considerable advantage in comparison to the concrete poles. The great advantage of these poles are the transport and installation works, because of the possibility to assemble the pole from several parts (assembling cone to cone).

However, it is important to note that these poles, when placed in aggressive environments, are susceptible to corrosion, which can be also overcome today by the use of high quality corrosion protection means.

The possibility of broadening the pole scope with lengths greater from 21 m and top hamper loadings of 2000 daN, under the conditions of axes symmetry, the hollow steel poles should be applied in erection of distribution overhead lines and be accepted as a standardized solution.

COMPARITION OF STRENGHT AND ELASTICITY OF CONCRETE AND HOLLOW STEEL POLES

The selection of materials for distribution overhead line hollow steel poles is based primarily on their mechanical characteristics: tension strength and pole bending elasticity.

Behavior of materials for poles

Reinforced concrete as a material for poles exhibits the susceptibility to brittle break.

Steel as a material for poles exhibit susceptibility to deformation without brittle break.

The relation between the elasticity of reinforced concrete and steel is given in Table 1.

TABLE 1 – The elasticity rate of reinforced concrete and steel poles

Pole material	Elasticity rates
reinforced concrete	100%
steel	315%

Hollow steel poles have very thin walls thanks to excellent quality of steel strength.

Hollow steel poles as well as concrete poles of equal lengths and equal rated loads upon equal top hamper loads have the similar values of declination.

Behavior of poles upon loadings up to the rated characteristics

The loading of the pole up to the rated characteristics should not lead to breakdown of the pole.

Besides, the pole breakdown through the safety coefficient is the rated characteristic of the pole. Pole elasticity, up to now, is not in the range of rated characteristics. That is due to the fact that great elasticity of the pole could lead to the loading of other components of the overhead line, the pole is not dimensioned for.

Typical damages of poles upon breakdown are given in Table 2.

TABLE 2 – Typical damages of poles upon bending breakdown

Pole	Typical damages of poles upon bending breakdown
concrete	breakdown, total or partial
hollow steel	breakdown due to a deformation

Breakdowns of pre stressed concrete poles occur upon extreme bending loads due to a damage of the concrete.

Breakdowns upon extreme bending load does not occur on poles made of classical reinforced concrete, although the damage of the concrete and armature deformation occur in the area of pressure.

Breakdowns upon extreme bending load occur on hollow steel poles due to the deformation, which can be prevented by building up the corresponding stiff elements.

COMPARISON OF DURABILITY OF CONCRETE AND HOLLOW STEEL POLES

Concrete Poles

Experiences of countries using great number of concrete poles indicate the number of damages was noticed in the procedure of load testing.

Damages

The main causes of external surface damage of concrete poles are as follows:

- internal mechanical disturbances occurring due to the: occurrence of internal strains, hygroscope and thermal shocks in the process of icing,
- chemical effects on concrete surface due to the environmental influences.

The protection of reinforcement of concrete poles is made by great amount of alkali components in concrete. However, carbon dioxide (CO_2) that is present in the air, penetrate the concrete making with alkali components calcium carbonate (process of carbonization), and steel reinforcement that is placed in such carbonate is not protected from corrosion and it corrodes.

Hollow steel pole in the role of angle support of single circuit 35 kV overhead line with the protection conductor

Shapes of the damages and their influence on pole loading

Web shaped or shaft shaped cracks are not considered as damages.

Crossed cracks occurring, as the effects of bending do not decrease the loading.

Damages of external surface of the pole cause the corrosion of armature. The damages of the armature decrease the loading of the pole.

Relation of the damages of concrete poles is given in Table 3.

TABLE 3 – Relation of damage types of concrete poles

Damage type		Relation of damage types of concrete poles
Cross-cracks		15%
Longitudinal cracks	cracks on mould links	46%
	other cracks	50%
Surface damages		16%
Armature damages		4%
Note: Out of the total number of concrete poles examined 11% has major damages, and 8% have lost their stability and were replaced or repaired.		

Repair of the damages

There are certain procedures for the repair of damage, and one of these is the procedure as per SAG, which returns to the pole its rated characteristic. The advantage of this procedure is as follows:

- decrease of the humidity effect on the internal part of the pole by ventilation of the internal part of the pole, that equalizes the inside and outside conditions,
- protection of external surface with epoxy resin reinforced with fiber glass, which restores the surfaces and closes the cracks, and at the same time protects that surface of the concrete from atmospheric conditions,
- protection of external surface with epoxy resin (paint), which restores the surfaces and closes the cracks, and at the same time protects that surface of the concrete from atmospheric conditions.

In order to restore the rated characteristics to the pole that is damaged it is necessary to build in many layers of fiber glass which can be determined by the computer program developed at the University of Essen.

Hollow steel pole playing the role of intermediate support of 10 kV single circuit overhead line prepared for further installation (insulators and conductors)

Production and dimensioning of concrete poles

The conclusions relating to the production and dimensioning of concrete poles are as follows:
- thickness of the external concrete protection layer should be greater than 25 mm,
- existence of ventilation in the internal part of the pole.

Hollow steel poles

Practice of the countries using a great number of hollow steel poles demonstrates the long life of poles protected by hot dip galvanization.

Corrosion protection

The hollow steel poles are protected from corrosion by hot dip galvanization having a minimal mass of zinc of 610 g/m^2 , corresponding to minimal thickness of zinc layer of s80 μm .

Life time of zinc layer

The speed of degradation of zinc layer is given in Table 4.

TABLE 4 – The speed of degradation of zinc layer*

Mark	Category of external space	Speed of degradation of zinc layer $\frac{\mu m}{year}$	
		from	to
C 2	rural area at the country side further from the sea coast (> 10 m)	0,1	0,7
C 3	urban area at the country side further from the sea coast (> 10 m)	0,7	2,0
C 4	industrial area at the in country side further from the sea coast (> 10 m)	2,0	4,0
C 5	area of high humidity and area by the sea coasts (< 10 m)	4,0	8,0

The restoration of the primer corrosion protection of hollow steel poles done by hot dip galvanization has to be carried out when the thickness of zinc layer is less or equal to 20 μm .

The lifetime of the primer corrosion protection of hollow steel poles done by the hot dip galvanization is given in Table 5.

TABLE 5 – Life time of the basic corrosion protection of hollow steel poles done by hot dip galvanization

Mark	Category of external space	Life time of the primer corrosion protection of hollow steel poles done by hot dip galvanization year	
		from	to
C 2	rural area at the country side further from the sea coast (> 10 m)	600	86
C 3	urban area at the country side further from the sea coast (> 10 m)	86	30
C 4	industrial area at the in country side further from the sea coast (> 10 m)	30	15
C 5	area of high humidity and area by the sea coasts (< 10 m)	15	7,5

Restoration of the primer corrosion protection

The restoration of the primer corrosion protection of hollow steel poles done by hot dip galvanization before all should be carried out by new deposition of zinc in hot dip galvanization. However, the other corrosion protection, so called duplex protection, is also possible, which is hot dip galvanization with protection paint that is possible to be carried out immediately after the installation of the pole.

Additional corrosion protection

Since the hollow steel pole is the most susceptible on transition earth – air in the area of ± 30 cm , it is necessary to protect that critical area of the pole with the paint of bitumen.

CONCLUSION PROPOSAL

Based on the characteristics of hollow steel poles presented in this paper, which shows that they are the least equal in comparition to concrete poles, although in many features have distinguished advantage, the following conclusions are proposed:

- The unconditional application of hollow steel poles is recommended for distribution overhead lines.
- On the level of Electricity Utility Company, the prompt creation of Technical recommendations for the application of hollow steel poles for distribution overhead lines is necessary.

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