EXPERIENCE WITH UPRATING 35 KV OVERHEAD LINE TO 110 KV VOLTAGE LEVEL USING POST LINE INSULATION

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ABSTRACT

Paper describes the first experiences gained during design and the implementation of the first compacted high voltage power line with post line insulators in Slovenia. The project goal was to take the advantage of using the route of way of the existing obsolete 35 kV transmission line in the way to restore it and upgrade to 110 kV voltage level in the future.

INTRODUCTION

Electricity distribution and reliable energy supply is one of the primary tasks of Slovenian power distribution company Elektro Gorenjska d.d.. Regarding environmental issues, planning and erecting of 110 kV lines is one of the most critical and complex company issues. Exposed to public opposition to erection of new HV power lines and different environmental resistances, Elektro Gorenjska is not immune to emerging spatial protection demands.

Based on the conclusions of network development studies, a new 110 kV supply line should be introduced in Kranjska Gora region. This region is well known as ski resort organising word ski cup. Exploring different opportunities, the refurbishment and upgrade of existent obsolete 35 kV overhead lines to 110 kV operation become one of the acceptable solutions. Having in mind, that simple substitution of rather light constructions of 35 kV overhead steel poles with typical 110 kV large steel lattice pylons would not be environmentally acceptable the new technological approaches were investigated.

Already having disappointing experience with severe public rejection of building new 110 kV power line, the 35 kV overhead line Jesenice – Kranjska Gora was chosen to be the pilot project. The valley of the upper Sava River, partly being a highly protected Triglav National Park area is very sensitive to the way of placement of new objects. The solution should provide minimal overall impact in that way that it would be acceptable to both environmental profession and the local population. First time in Slovenia was introduced the compacted overhead line made from steel poles with post line insulation.
The paper presents first experience gained during the design and erection of compact 110 kV transmission line with post line insulators. Compacted treatment was developed and designed to be placed in an existing 35 kV power line corridors in a way to preserve the natural and landscape painting as much as possible. Project in that way represents first attempt of environmental and technological optimized design of 110 kV overhead line in Slovenia.

PROJECT DESIGN PHASE

Tower design

The technical solution should provide minimal overall impact in that way that it would be acceptable to environmental profession and the local population. Using existing towers locations was one of the first decisions that had defined the appropriate design of the overhead line tower. The existing suspension towers were made from double wood poles, and angle towers are steel lattice towers. First the different tower designs was studied as shown in Figure 1.

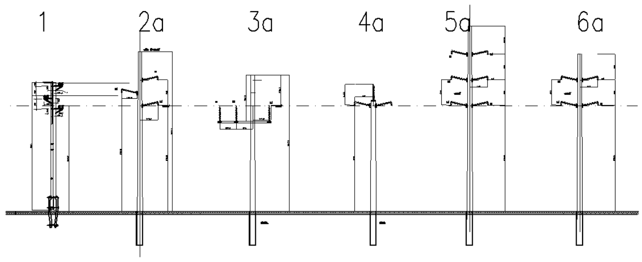

Figure 1: Studied possible tower types.

The electromagnetic impact of a new 110 kV line on environment was also studied in parallel. The impact should be inside regulated values in existing rout of way. The electric and magnetic fields were calculated for different tower types as shown in Figure 2. Note that in Figure 1 tower named 'steber 1' use 35 kV voltage, and the rest towers110 kV voltage in calculation.

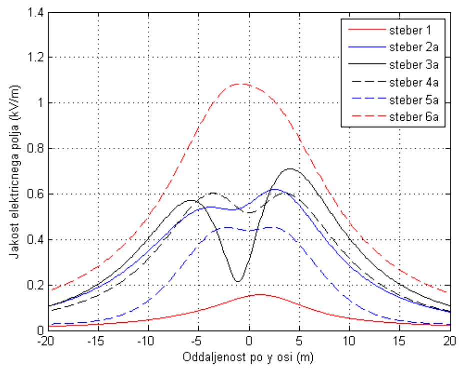

Figure 2: Calculated electric fields of different tower types.

The results showed the conformity of the solution regarding Slovenian EMS regulation.

Trying to remain approximate dimensions of existing wooden towers the decision to use rigid post line insulators on new polygonal towers was taken. Figure 3 shows the strong similarity with the existing pillars. Dimensionally speaking, the towers are near existing, which provides us with a minimum of visual changes in spatial and is therefore seen as a viable option to implement.

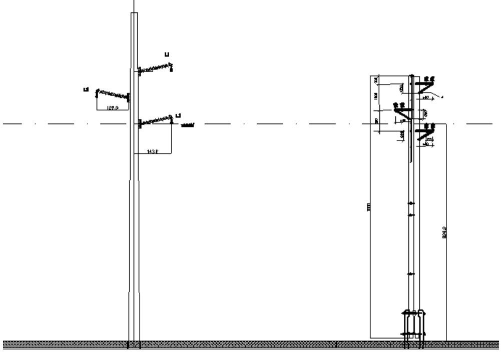

Figure 3: Similarity between 110 kV and 35 kV tower.

The decision was confirmed by obtaining environmental permission based on similarity of towers.

Conductor selection

Basic decisions when planning new or uprating existing connection is required transmission capacity. Usually by the network developers starting point for planning power capacity at 110 kV level is 100 MW. That power resulting from the conductors 240/40 ACSR transmission capacity. Analysis of actual needs often reveals that such initial delegated power is not really needed and can be smaller. That is more true to particular 110 kV substations designed to cover the distribution power demands with transformers in range 20 MVA [1]. So for the pilot project it has been decided that in long term prognosis for next 30 years, conductors 120/20 ACSR can be used. With that decision major reduction in tower strength and consequently reduction in tower weight can be achieved.

Tower heads

On the basis of longitudinal overhead line profile we determine two average (wind) spans to determine required statically tower strength. These are the 125 m and 170 m. To determine dimensions between conductors in tower head we use special simulations rather than standard equation to determine required distances. To employ vertical distance as most critical we made simulation of ice shedding scenarios. Considered model is illustrated in the Figure 4. Based on the simulations we choose the mutual vertical spacing between conductors to be 3 m for both average spans. Horizontal distance is check based on the conductor's movement in wind. Consider two conductors on the left conductor works full wind (600 Pa), on the right only 60% of the full wind. Minimum required spacing is 148 cm, so we can use post line insulators directly fixed on towers.

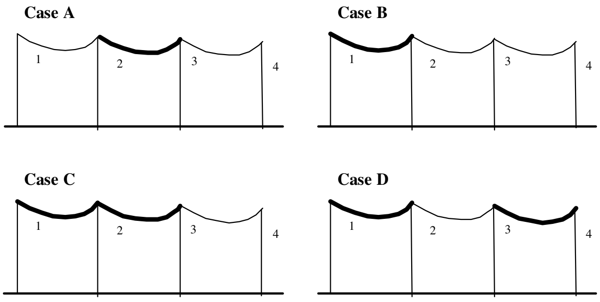

Figure 4: An example of loads handled guides

Steel pole

The choice of wind and gravity span is carried out on the basis of the analysis of longitudinal profile. Both data are important for determining the mechanical properties of the tower. For gravitational span were taken value 1.8 times the wind span. Mechanical tensioning of conductor is 90 N/mm^2. As we approach the dimensions of the existing pillars, in first design stage was made rough polygonal tower static design. The basic dimension, the steel thickness, the polygon number was determined. Later at final design stage statically calculation were made and final adjustments made and demonstrate that the tower construction meets all requirements given by the standard SIST EN-50341. The chosen steel material 355 bent in twelve brackets is used. By this approach towers mass are in class from 900 kg to 1300 kg. Dimensions are given in Figure 5.

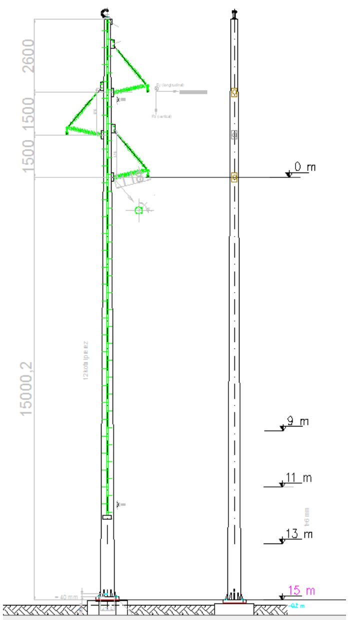

Figure 5: Steel pole dimensions.

Post line insulation

Although the subject is renewal of 35 kV transmission line in first, the installation of longer insulators that allow operation at 110 kV voltage level is required. Selected standard atmospheric lightning impulse 1,2/50 µs is 550 kV and standard switching overvoltage is 230 kV. As an electrical demand is relative easy to satisfy the mechanical properties require special treatment. Insulator must therefore satisfy the so-called combination of horizontal, vertical and transversal loads.
It turns out that the critical are ice shedding loads, which most affects to the longitudinal forces. Detailed analysis of the calculations showed that the standard EN50341 here is behind the progress of technology. Critical is the definition of way to determine force on isolator. Using classical approach the forces overcame allowed given from insulator manufacturer. It turns out in fact that the longitudinal forces using flexible calculation are significantly smaller as the conservative European approach in the forces calculation. Figure 6 illustrate the used concept of flexible line. It should be noted that our insulator are fixed on tower and not turn able (pivot) insulators. The approach introduces to the calculation a flexible transmission line. This means we are taking into account structures bending under different loads that are acting on the structure. The flexible line in (right), named M III, can be imagined as steel poles, where the bending of the pole is clearly evident.

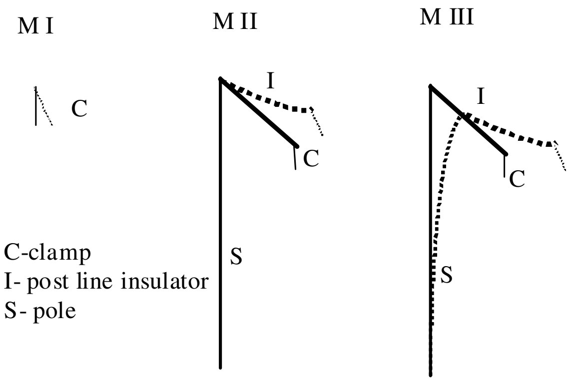

Figure 6: Flexible line koncept study.

It turns out that the mechanical characteristics to our need determine the length of the insulator to 1.25 m and the core diameter 63.5 mm (2.5"). That corresponds to our static analysis of the situation on the route. Provided for the installation of a post insulator, Figure 7, in the event that post insulator is not enough mechanical strong, or when the standard requires mechanically reinforced insulation, the suspension insulator is add the post line insulator.

Figure 7: Post line insulator during conductor clamping.

The safety factor for the insulators was taken to be 2. Permissible forces are check by for confirm allowable maximum design cantilever load. Insulators are attached to the column via a standard flange.

Foundation and pole erection

The steel poles are foundated by concrete block foundation through anchoring bolt basket as show Figure 8a. The approximate foundations dimension are 2,6x2,6 to 3,2 to 3,3 m regarding soil characteristics. Working site is small as show next figure 8b.

Figure 8a and 8b: Foundation during and after works.

The steel pole erection is made with appropriate lifting truck as show Figure 9. The final assemble and erection of take only one day for three steel poles. Compared assemble time between steel lattice towers and steel poles, the second type is much smaller.

Figure 9: Steel pole erection works.

Final appearance

The pilot project overcame our expectations. We achieve that environmental experts and local people accepted realised line section with positive comment. Also line is almost the same as before and it is not a new foreign structure in environment. To show difference the picture 10a and 10b should be compared. The dimensions at the ground are almost the same.

Figure 10a and 10b: Line before and after uprating.

CONCLUSIONS

From activities carried out in design and construction phase of project so far we can make the following conclusions:

- The use of such technologies is the appropriate alternative to use existing middle voltage route of ways for uprating to higher voltage,
- It is confirmed that uprate existing route of way is much more acceptable as putting new one into space,
- It is necessary to step out from classical designing approach which too much times based on using typical steel constructions,
- To obtain the optimal design of steel poles for concrete route of way the custom made steel poles could be easy constructed,
- In determining internal distances between conductors it is necessary to perform more simulations, because control with classical mutual distances equations give conservative results,
- standard EN 50341 should require amendments regarding the definition of loads on post line insulators introducing flexible lines,
- The local people accepted new structure in their space with positive attitude, because of small visual difference regarding existing line.

The constructed section is regularly monitored and after 1,5 years' operating time on middle voltage no problems occurred. Constructions of next sections are following in the next years. .

REFERENCES

[1] B. Zemljaric, 2011,"Compact *towers with post-line insulators designed for snowy areas*", *Proceedings, IWAIS 2011*, Chongqing,

[2] "Overhead electrical lines exceeding AC 45 kV. General requirements" EN 50341-1:2001, Cenelec.