# WOOD POLES FOR POWER LINES THEIR USE WORLDWIDE AND REMOVING IMPEDIMENTS TO THEIR USE HERE

by

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## 1.0 The use of Wood Poles is Environmentally Friendly

1.01 The very mention of wood poles as power line supports often evokes strong emotions from many members of the public. They fear that such use will further denude the very limited natural forest cover of this country and aggravate the unabated environmental degradation that is going on. The fact is quite the contrary.

1.02 It is true that initially Hora, an endemic species, growing in natural forests was used for the production of wood poles. But now, only exotic softwoods grown in man made forests are used for such production. There is thus no cause for concern about natural forests.

1.03 Man made forests are as a rule dedicated to the production of logs for the sawn timber trade which provides planks and squares for use by the furniture and building trades. The sawn timber trade requires logs that are straight, long and large in diameter, and free of knots to minimize the losses of conversion, so man made forests needs must provide such logs.

1.04 The established way of ensuring that the logs obtained from the final harvest conform to these requirements is to start off the plantation with the seedlings spaced about a metre apart. The close spacing encourages competition and the dominant individuals grow taller than the others. The weaker ones are then removed creating space for the dominant ones to grow steadily. This process is called "thinning" and is repeated twice or thrice before the final harvest.

1.05 If such thinning is not carried out the plantation will simply degrade into scrub as has happened to a few thousand hectares of Pinus Caribea.

1.06 The early thinnings are so slender that they can only be used as firewood. The latter thinnings are useful as fence posts and props. The final thinnings can serve as line supports. Thinnings not used in some such way end up being burnt or allowed to decay on the forest floor.

1.07 It is understood that at present the bulk of the final thinnings are being used as fence posts and props and only a small number are being utilized for the production of wood poles. Fence posts and props fetch a low price, have a short service life and are then left to decay or are burnt.

1.08 Wood poles on the other hand have a long service life. Further it is their light weight that helps the nation to provide electricity to rural communities in hilly terrain. The shortfall in the supply of wood poles has forced the CEB to import poles at great cost. The conversion of the bulk of the final thinnings into wood poles will promote electrification and industrial growth. Thinnings suitable for such conversion will fetch a higher price for the forestry sector.

1.09 The thinning of man made forests is vital even where the seedlings have been planted further apart than suggested above. The disadvantage of greater spacing is that saplings tend to branch out and this ends up as knots in the logs, adding to the wastage in sawing.

1.10 Clearly therefore, wood poles used as power line supports do not deplete natural forests. Such usage ensures better quality logs for the sawn timber trade and improves the viability of the forestry industry.

## 2.0 The Worldwide Use of Wood Poles as Line supports

2.01 Wood poles were no doubt first used as supports for telegraphic lines. The need for secure telegraphic lines made the British Post Office codify how wood poles may best be deployed, as well as how they may be treated to protect them against insects and fungi. Much of this early practice has been adopted in the construction of power lines.

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2.02 In the UK all power lines at 33 kV and below are built on wood poles. The number of countries that use wood poles as line supports is too numerous to be listed here, so just a few are given below.

2.03 Sweden, Norway and Finland construct power lines upto 220 kV on wood poles. In the Americas, particularly in the tropical belt wood poles have been used because they are known to perform better under severe conditions of lightning. Malaysia, Australia and South Africa use wood poles for the same reason.

## 3.0 Wood - Some General Engineering Considerations

3.01 The awareness in this country - among engineers as well as the public - that wood is of varying strength and quality, and perishes in a short time, has inhibited the use of wood poles for line construction. Perhaps a quotation from "Timber Its Structure and Properties" by H E Desh will help in understanding how others have come to use wood poles.

"Research into the properties of timber is one of the most pertinent factors in enabling wood to hold its own today, second to none, for so very wide a range of quite different end uses. The practical significance of our knowledge of wood has, however, yet to be fully appreciated, and generally applied. It is too often assumed that generations of practical experience have taught users all there is to know about a material in such general use."

3.02 The tenor of that quotation is that the practical experience of generations of mankind needs to be supplemented by the new knowledge gathered over the early decades of this century to ensure the better use of timber. As the focus of this paper is on power line usage it will begin with the electrical characteristics of wood poles which has brought about their use in the freezing north as well the hot humid tropics for power lines.

3.03 Line supports are subject to wind and other mechanical loads, so the next aspects considered is the mechanical characteristics of wood poles.

3.04 The processes of growth and the nutriments available made trees of the same species growing alongside differ from one another. Some have defects which affect their strength, and others have defects that make them prone to decay so it is important to establish a process of selection that defines defects and specifies the type and limit of defects acceptable.

3.05 Except for one or two species of timber, wood when exposed to the elements decay. To prevent wood poles from decay it is necessary to treat them with chemicals. The options available are thus discussed.

3.06 As the purpose of producing wood poles is to deploy them on lines, how this is done will be outlined next.

3.07 Finally what needs to be done to remove the constraints that hinder the use of this valuable national resource will be discussed. Then attention will be drawn to the benefits that would accrue by a coordinated action plan that ensures careful production and the proper use of wood poles.

## 4.0 Electrical Characteristics of Wood Poles

4.01 A measurable characteristic of any material is the extent to which it will resist the passage of electricity through it. Those that have low resistance such as copper and aluminum are classed as "conductors", and those with high resistance such as ceramic materials and many plastics as "insulators".

4.02 The resistance of materials varies with the form of electricity (DC, mains frequency AC or high frequency AC) applied to it. It is thus usual to specify to which form any given resistance value is relevant.

4.03 The various multi conductor arrangements that carry mains frequency AC such as overhead lines, and cables are known - to put it in simple terms - to make the passage of electricity more difficult. This is called "impedance" to distinguish it from the pure resistance of materials.

4.04 Overhead lines and their supports are subject to lightning which often causes high frequency short duration discharges - impulse discharges - from the conductors down through the supports to earth. The impedance offered by supports to lightning is thus termed "impulse impedance" to distinguish it from normal mains frequency impedance. This country is subject to frequent and high intensity lightning so the impulse impedance of line supports is of considerable importance.

4.05 Steel and concrete have low impedance to mains frequency AC as well as to lightning impulses. Thus, lines made of these materials are generally required to have an overhead earthwire, and be properly earthed in the hope that lightning would take the easier path through the earthwire

to earth. The purpose of this arrangement is to prevent lightning striking the line directly and damaging the insulators and consumers equipment.

4.06 Wood pole lines constructed in most countries are exempt from both the provision of earthwire and earthling because wood poles provide supplementary insulation - importantly their impulse impedance remains high even when they are wet. This results in unearthed wood pole lines having far fewer power failures - a usual sequel to lightning strikes on earthed construction with other forms of supports. This is confirmed by studies in America and Australia.2,3 and 4

4.07 One of the problems noticed with unearthed wood pole lines in countries where lighting is severe is the burn out of wood where wood and metal are attached - insulator pins bolted to wood crossarms, steel crossarms bolted to the pole. To overcome this a form of unearthed construction called "all insulated construction" - where wood insulator pins and wood crosarms are used - was developed and is said to perform very satisfactorily.

## 5.0 Mechanical Characteristics of Wood Poles

5.01 Timber is made up of long fibers laid down in the processes of growth. These processes not only vary somewhat from species to species, they are also constrained by the availability of nutriments, water and sunlight from tree to tree within any plantation. The results in individual poles having somewhat different mechanical capabilities.

5.02 As a general rule however, timber has considerable strength in tension, but its compressive strength is low. The bending strength of a pole, which is of importance for the majority of supports on lines lies between its capability in tension and compression. Further, the fibrous structure of wood poles makes them very flexible and enables them to take very high impulse loads - about 8 times their static load capability.

5.03 The strength of a piece of timber varies with the species of timber - as the structure varies from species of species, with the rate of growth of the tree from which it was obtained, and the moisture content at the time of test. Further any defects in the timber will reduce its strength. Tests are therefore carried out on a large number of small, clear (with no defects) specimens of a species by national laboratories for establishing the timber strength of a species grown in the country.

5.04 It is not practicable to obtain a wood pole without defects, so the test results on small clear specimens have generally been viewed with caution by those using wood poles. In Britain, Finland, Norway, Sweden, USA, South Africa, India, Australia and New Zealand tests have been carried out on a large number of poles of different species and their minimum strengths established. National specifications now give the minimum strength of the various sizes of poles of each species grown and used in the country.

## 6.0 The Electrical and mechanical Loads on Pole Supports

6.01 The insulators on line supports are normally adequate to cope with the electrical stress of he energized conductor. As explained earlier wood pole line supports provide the supplementary insulation needed to minimize outages due to lightning. The supplementary insulation provided by wood poles of all sizes and species is in general adequate for dealing with all but direct strikes of lightning which are fairly rare.

6.02 The mechanical load varies from support to support along lines and there are static loads as well as impulse loads, though for design purposes all loads are taken to be static. As wood poles have a very high impulse load capability, the practice of treating impulse loads as static loads in designing makes wood pole lines more secure than other pole lines.

6.03 Poles in straight line positions are required to carry the weight of the insulators and the hardware and some part of the weight of the conductors of he spans on either side of it - really the weight of the length of conductors up to the lowest point of sag on either side. They are also required to carry the wind on themselves, insulators, hardware and half the conductors of the spans on either side.

6.04 In angle and terminal positions supports are required to carry the weight and wind loads set out above and the load resulting from the pull of the conductors attached to them. The fixing of stays to such supports helps keep them vertical but increases the compression or crippling load on them. As the capability of wood in compression is lower than that in tension, supports in such positions need to be chosen with particular care.

6.05 Spans generally vary along lines. As the weight and wind loads vary with the span lengths on either side of a support, supports that have short spans are subject to light loads. Supports with large spans on either side and angle and terminal supports have higher loads. An advantage of wood poles is that they come in wide range of sizes, so it is not difficult to match the pole to the line load. Poles of other materials that are fabricated or manufactured come in a few fixed sizes, so that a larger pole than that actually required has often to be used.

## 7.0 Criteria for the Acceptance of Wood Poles

7.01 As stated earlier species that provide valuable timbers are not used for the production of wood poles. Further, though a number of species are listed in national wood pole specifications few countries deploy more than one or two species. Availability, a very limited variability in strength, a minimum of defects, and ease of treatment are qualities that finally establish the species that become popular within a country or region.

7.02 Essentially wood poles are a natural resource of a country grown and used within the country on a pragmatic basis backed by careful engineering investigation. A small number of wood poles grown here are being used but their treatment and deployment fall far short of good practice.

7.03 Criteria for the acceptance of wood poles vary from country to country because wood poles are a natural product of the country or of the region. A striking example is the acceptance of end (top and bottom ends) splits, caused by the very dry climate in Australia and South Africa. The low humidity in these countries also inhibits the growth of fungii and so the acceptance of poles with end splits seems reasonable.

7.04 In the UK however, where the climate is somewhat humid there is greater danger of fungal decay and so the BS seeks to exclude end split poles. In Europe the standard pole used is Pinus sylvestris grown in Scandinavia (Norway, Sweden and Finland). this species or tree grows slowly in the cold north of Europe and the slow growth ensures compact and uniform timber and freedom form splits. Considerable numbers of these poles have been exported to African countries.

7.05 There is considerable variation in the choice of species and in the criteria of acceptance of poles from country to country. Thus even though poles undergo some industrial processes or manufacture they are not a uniform manufactured product whose performance in a new climatic situation is easily predicted.

7.06 This country is hot and humid. The hot sun tends to cause uneven drying when freshly felled poles are exposed to it. The high humidity encourages bacterial and fungal growth so it is the practice to use a clawed plate at the bottom end of freshly felled poles to prevent splitting. The subsequent slow air drying does not cause splitting. As in the case of other countries the best poles for processing and use here, are those that have grown here.

## 8.0 Preservative Treatment

8.01 There are two preservatives commonly used. One is coal tar creosote, and the other copper chrome arsenic in an aqueous solution.

8.02 There are several processes of treatment, but the most effective ones are pressure treatment processes. Other processes such as dipping and brushing do not ensure durability, and such others as sap replacement processes waste a lot of the preservative. 11

8.03 Experimental evidence and experience indicate that the best preservative for wood poles is coal tar creosote and that the most effective way of application of coal tar creosote is the Rueping "empty cell" pressure impregnation process. The Rueping process ensures that the surface of the pole is dry (free of preservative) at the end of the process.

8.04 Copper chrome arsenic is an effective preservative but is considered hazardous. It also tends to leach out in places subject to heavy rains. it is best applied by the Bethel "full cell" pressure impregnation process.

8.05 Even when the pressure impregnation processes ar used the extent to which the preservative permeates into the pole depends on the species of the pole. In the case of Pinus sylvestris the whole of he pole (inclusive of the heartwood) could be treated. In the case of some of the species used in Australia not even all the sapwood could be treated. These differences are often catered for in national specifications.

## 9.0 The use of Wood Poles in Sri Lanka.

9.01 During the mid 1980's the IESL (Institution of Engineers, Sri Lanka) conducted 3 Seminars of relevance to the ESI (Electricity Supply Industry).

These focused on trees, wood poles and overhead line supports. 6,7 and 8 These seminars drew attention to the fact that wood poles (treated with creosote) had been imported from the UK in 1938 and used in the Diyatalawa area and that some of them were in service. Another fact that emerged was that under Canadian aid poles treated with a water bourn preservative had been deployed in the early 1950's in Gal Oya.

9.02 The use of locally grown and preservative treated poles begun in the mid 1950s. But it did not get off to a good start, for the specification was written around a very high minimum size of pole and Hora was the only accepted species. Further, though coal tar preservative was used, it was diluted with furnace oil and the method of application was the Bethel process which made the poles slippery and difficult to handle. Now locally grown exotic species have been accepted, and some other sizes added.

9.03 The seminars revealed that the specifications, the arrangements for production, and perhaps because of the small numbers produced, the cost per cubic foot of treated pole excessive - more than the market price of a cubic foot of jak. An outcome of these seminars was the setting up of a Committee, by the SLSI (Sri lanka Standards Institution), for he drafting of specifications on Wood Poles.

9.04 The Drafting Committee studied several national standards in particular the differences in the criteria of selection, the methods of fabrication, the options in regard to preservatives and processes, the methods of testing and the various ways of classifying poles for purposes of deployment on overhead lines and after careful consideration of the specific circumstances in this country drew up 8 standards.

9.05 Six of these have now been issued as SLS standards. 9 and 10 The two specifications that dealt with preservative treatment using copper chrome arsenic have been held over because of environmental concerns. A special feature of the SLS standards - not found in any other national standard - is the codified classification, of all the species of poles adopted by the standards, according to length and load capability. This will greatly facilitate deploying them on power lines.

9.06 One of the difficulties the Committee had in so codifying the poles was the total lack of test results on poles as such. To overcome this difficulty the Committee examined the general relationship between clear specimen test and pole strengths in other national timber and wood pole specifications and suitably adjusted the test values of the clear specimen tests done on poles grown in this country for its purposes.

9.07 Though the standards were agreed to by the Timber Corporation, the CEB and the Telecommunications representatives on the Drafting Committee, regrettably not a single pole has been ordered or produced on the basis of these standards. Thus ad hoc practices adopted decades ago continue and tens of thousands of poles that could possibly be used as line supports continue to be burnt.

9.08 Perhaps a comprehensive manual on the basis of internationally accepted criteria for wood pole line design for the different voltages and conductor sizes used in this country will be helpful in promoting the greater and proper use of wood poles.

## 10.0 Using a natural resource for the Nations' Benefit

10.01 As spelt out earlier importing wood poles into this country would not be satisfactory. The hot and humid climate of this country make fungi and other destructive micro organisms abound. There is thus a need to specify poles that are not subject to splits and cracks and other defects that facilitate the entry of fungi into the core of the pole. This rules out poles from dry climates.

10.02 Only poles from the cold regions for the world where growth is slow are free from splits and other defects would be satisfactory. But these are expensive, and they entail considerable costs in transport. Further, importing such poles - or any wood poles for that matter - does not make much sense in the context that this country has thinnings that could be treated and used.

10.03 The prime difficulty so fat has been that the supply and use of poles has been largely a matter between government organizations - Forest Department, State Timber Corporation, CEB and Telecom. These organizations have other and wider priorities and the production and use of wood poles is but a small part of their activities thus none of them are really committed to such production or use.

10.04 Privatization of these state organizations has been talked of for long but no progress has been made because of various objections. Creating a corporate body under the Companies Act with largely private sector funding and foreign

know how, will possibly marginally affect the activity of the State Timber Corporation - they produce some 15,000 poles per year.

10.05 The entry of the private sector into the production of wood poles will ensure that thinning of man made forests are done on time, that productive use is made of all thinnings and increasing the production and use of wood poles to about three or four times the present number within an year or two. It could also spearhead a drive for improving the forestry industries and the production of logs for the sawn timber trade.

10.06 If the necessary political will is forthcoming, there is little doubt of the production of poles becoming a nationally beneficial activity.

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