International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

L.88

(07/2010)

SERIES L: CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

Management of poles carrying overhead telecommunication lines

Recommendation ITU-T L.88

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Management of poles carrying overhead telecommunication lines

Summary

A telecommunication pole is one of the most important network infrastructures used to carry overhead telecommunication lines.

In wooden poles, as support of communication lines, the following circumstances are present:

The wood, when the antiseptic efficiency of the preservative treatment has decreased below the threshold, is subjected to the attack of biological agents that cause its destruction.

Healthy wood of poles must preserve the mechanical strength that line security requires.

The heavy cost of wooden poles as well as of pole replacement requires conservation to extend the life of the poles, while paying sufficient attention to worker safety and the expected lifetime of the poles. This can be achieved by means of different systems such as reimpregnation, lowering, recover and reclassification.

Another material used in common utility poles is concrete. These poles are planted into the ground, but in some cases, they lean or are overturned by forces such as strong wind. This phenomenon is mainly due to a foundation failure. Recommendation ITU-T L.88 deals with integrity testing for telecommunication pole foundation.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T L.88	2010-07-29	15

Keywords

Creosote, non-destructive testing (NDT), resonance frequency, telecommunication pole.

FOREWORD

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Management of poles carrying overhead telecommunication lines

1 Scope

This Recommendation:

- describes how to measure the magnitude of attacks in poles;
- describes how to unearth a pole;
- describes integrity testing to identify the base condition of telecommunication poles;
- describes integrity testing which includes a non-destructive testing method;
- describes integrity testing for precast concrete poles that are planted into the ground.

2 References

None.

3 Definitions

3.1 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.1.1 concrete: An artificial, stonelike material used for various structural purposes, made by mixing cement and various aggregates, as sand, pebbles, gravel, or shale, with water and allowing the mixture to harden.

3.1.2 creosote: Wood creosote is a colourless to yellowish greasy liquid with a smoky odour and burned taste. Wood creosote is used as a wood preservative and has also been used as a disinfectant, a laxative, and a cough treatment.

3.1.3 non-destructive testing (NDT): This method detects defects such as cracking and corrosion, not destroying the test object. There are different methods of testing available, such as the ultrasonic pulse velocity method and the stress wave propagation method.

3.1.4 resonance frequency: Resonance is the tendency of a system to oscillate at maximum amplitude at certain frequencies. When damping is small, the resonance frequency is approximately equal to the natural frequency of the system, which is the frequency of free vibrations.

3.1.5 unearthing: Action of digging out the earth.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviation:

NDT Non-Destructive Testing

5 Conventions

None.

6 Management of poles carrying overhead telecommunication lines

6.1 Overview of wooden poles management

Creosoted poles must be inspected periodically and, depending on their state, they may continue in service or be replaced.

In order to prolong pole lifetime, it is advisable, provided that the authorized products exist, to treat them or reimpregnate them.

It is recommended that the inspection and reimpregnation activities be carried out simultaneously because, amongst other reasons, the area most prone to attacks is under and just above earth. In order to make a good inspection by traditional methods, it is necessary to unearth the pole and, because once unearthed, the aeration of the land increases the danger of attack by microorganisms. As a result, it is also necessary to reimpregnate that area to counteract the aforementioned danger.

Because of the fact that it is not advisable to use reimpregnating products on a large scale, inspections should be done without unearthing the poles and only in those cases where the previous examination brings up doubts about the state of the pole; the pole should be unearthed in order to inspect the buried part.

Whenever a pole is unearthed, it should be treated with a phytosanitary treatment, or any other authorized product.

The maximum period between inspections should be 5 years.

The dry season is the most favourable season of the year for inspection works; consequently, climatological regional conditions should be taken into account before setting the inspection dates.

6.2 Wooden poles inspection

The antiseptic power of creosote must be guaranteed by the creosoted pole supplier for 10 years; for this reason, poles must be inspected before this period expires and, depending on their state, would continue in service or be replaced.

As previously stated, the most suitable season for inspection works is the dry season.

Before proceeding with an inspection work on a pole, the land around it must be cleaned, and afterwards 2 or 3 cm around it can be scratched.

The inspection data will be written down and collected.

It is mandatory to inspect a pole before climbing it

The poles in bad state should be marked with a red disc of a diameter of 10 cm, whose meaning is: "DANGER; DO NOT CLIMB". These poles must be dismantled as soon as possible.

Apart from periodical inspections, the lines that are the object of big refurbishments, such as changes in emplacement, should be inspected.

The operations to be done in a pole inspection will be detailed below:

6.2.1 Materials

To unearth the pole, apart from the properly established tools, it has been shown that the most useful tools to use are a pickaxe and a hoe, or a tool that combines both.

The necessary materials to inspect a pole are the following:

– 1.5 kg hammer.
– 20 cm drill probe.
– Tape measure.

– Tool to scrape the pole's surface such as a chisel.
– Depth slide gauge.
– Thickness slide gauge.

6.2.2 Visual inspection

Before proceeding with the inspection, an initial evaluation of the resistance of the pole as well as of its embedment should be carried out. For this purpose, the pole should be repeatedly pushed hard with the hand.

The visual inspection of the pole should be done thoroughly over its entire surface, from the base to the head, to detect the presence of any of the following defects:

– Bird attack.
– Small holes (made by insects) of 1 to 2 mm in diameter.
– Presence of knots.
– Stretch or fracture of fibres.
– Fungus or insect attack.

Examination for possible deficiencies related with the line, such as braces, installed elements, etc., should be undertaken in order to put forward the appropriate conservation works.

6.2.3 Inspection by percussion

The pole should be hit using the appropriate hammer. Depending on the impact and the sound produced, the state of the pole can be determined.

A "healthy" pole, with a good density of wood, produces a hard impact with some rebound, and a clear and vibrating sound.

An "attacked" pole with cavities, and differences in wood density, produces a muffled and muted sound.

However, the different tonalities produced due to the nature of the land, the embedment of the pole, the installed elements and the climatological conditions should also be taken into account.

The appreciation of the different tonalities is acquired through the adequate preparation and/or practise.

The exploration with a hammer should be done from the base (earth line if the pole is not unearthed) to the height reached by the arm. In special cases, the examination can be extended to higher areas, by climbing with the assistance of climbing irons and assuring beforehand the solidity of the pole.

6.2.4 Attack measurement

Once the affected zone is detected, the magnitude of the attack is determined by means of direct measurement in the case of external attacks and by drill probe in internal attacks, with the help of the appropriate gauges.

When the examination of the pole is complete, the holes made with the drill must be sealed with wooden pegs of creosoted wood of 60 mm length and 15 mm of diameter, with a pointed tip of 10 mm.

6.2.4.1 Operating with the drill probe

To determine the inside state of the pole, a drill probe should be used. Operating with it is easy:

Once drilled to the desired depth, an extracting "spoon" is introduced in the drill's rod, sliding it between the inside surface of it and the wooden control. Turning it completely anticlockwise causes the extracting "spoon" to be extracted with the wooden control inside it.

Figure 1 – Operation with the drill probe

Sounding should always be done in the radial direction; the depth should be determined by the measurement and should be repeated for the best quantification of the attack.

Before introducing the drill probe, it should be checked that, at the selected point, there are not any nails or knots or any other obstacles that could damage the tool.

6.2.4.2 Operating with the gauges

The gauges are steel rod wire punches graduated in centimetres.

The depth gauge, operated as a punch, helps to determine the depth of an external cavity, or an internal cavity made accessible by the drill probe. The wood at the bottom must always be tested down to healthy fibres, keeping the cut of the gauge horizontal to the ground, since the wooden fibres are longitudinally vertical.

The *thickness gauge*, with its tip bent at an angle of 90 degrees, is designed to measure the thickness of healthy wood in an internal cavity and also the thickness of healthy wood in a visible cavity. In the first case, the gauge is introduced in the hole left by the drill probe, and, in the second, it is directly applied to the edge of the cavity using the sharp right angled edge of the gauge.

6.2.5 Wood pole unearthing

If, when the previous operations have been carried out on the pole without unearthing, there is still some doubt about the state of the pole, it should be unearthed and the unearthed area inspected.

The pole unearthing consists of digging, using the appropriate tools, a hole of 50 cm deep and 35 cm radius around the pole.

With the pole unearthed, prior to inspection, the earth adhering to the surface of the unearthed area should be removed, and in the case where the pole has any paper or plastic band adhering from a previous treatment, it should be removed and eliminated according to the current legislation.

Then the inspection should be conducted following all the steps indicated in the preceding clauses (visual, percussion, external attacks and internal).

Once the inspection is complete, the unearthed area should be protected as well as the area immediately above the soil line, such protection shall be conducted with approved products and systems. Subsequently, the pit must be filled and compacted.

6.3 Integrity testing for concrete telecommunication pole foundation

6.3.1 Conventional methods

6.3.1.1 Visual inspection

This method consists of detecting tension cracks or bulging parts of the ground in which the pole is planted (see Figure 2). Measuring the depth of embedment and checking the degree of compaction can be used.

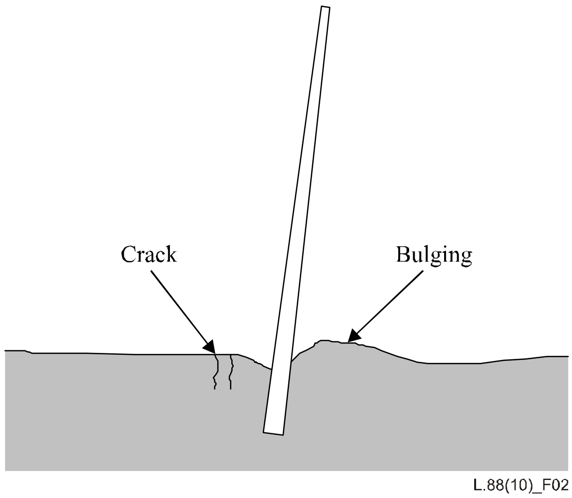

Figure 2 – Visual inspection

6.3.1.2 Instrumentation

This method is applied when a telecommunication pole is inclined excessively. To ensure that the inclination of the pole does not exceed a certain limit, a transducer that can monitor the change in inclination (rotation) is installed at the side of pole (see Figure 3).

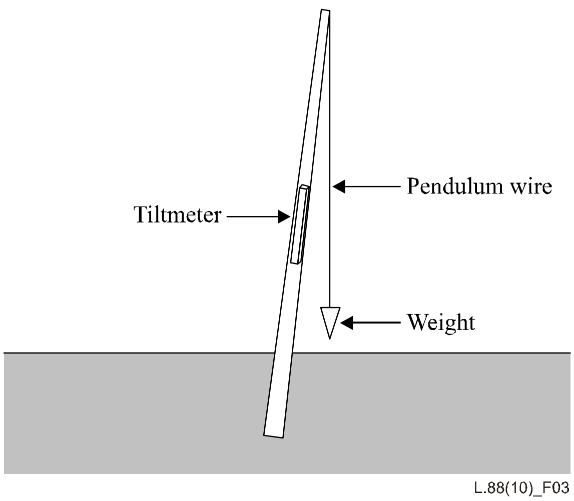

Figure 3 – Instrumentation

6.3.2 Non-destructive testing (NDT) methods

6.3.2.1 Resonance frequency method

6.3.2.1.1 Test setup

The equipment consists of an accelerometer and a data acquisition system. An accelerometer is tightly mounted at the side of pole with adhesives or bolting. A typical test configuration is shown in Figure 4, where D is the embedment depth of the pole, H_1 is height from the ground to the impact position, and H_2 is height from the ground to the accelerometer. These values vary depending on the length of pole.

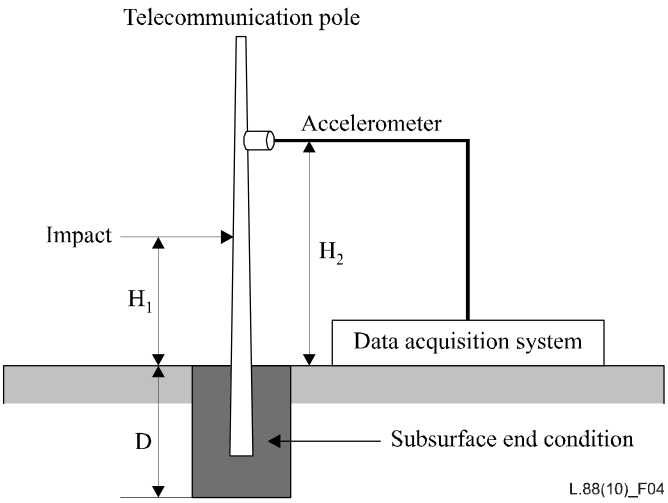

Figure 4 – Typical test configuration

6.3.2.1.2 Data processing

A pole vibrates freely when impact load is applied in the horizontal direction. Free vibration is easily achieved by pushing the pole repeatedly. The vibration waveform is captured by an accelerometer and a frequency spectrum is obtained by taking the fast fourier transform (FFT) of the time domain waveform. From this, the first peak of the resonance frequency (that is closely related to the base condition of pole) can be obtained.

6.3.2.1.3 Analysis

The first peak of the resonance frequency is a key parameter to identify the quality of the telecommunication pole's foundation. If the pole's foundation is strong, the first peak is at a high frequency. Whereas if the pole's foundation is weak, the first peak is at a low frequency. For this test, it is necessary to establish several reference peaks for telecommunication poles beforehand.

Appendix I

The Spanish experience with poles management

(This appendix does not form an integral part of this Recommendation)

I.1 Poles used for telecommunications in Spain

Wooden poles are the ones mostly used in Spain for telecommunication lines. Concrete poles are also used in some situations, such as beginning and end of lines, changes of direction and, in general, difficult situations.

The distance between poles depends on the height, wind and weather conditions, but the maximum span is 40 metres for drops and 80 metres for fibre or copper cables.

In the following clauses, there is a description of the main problems found in the wood of these poles. This information helps in identifying an attack.

I.2 Agents and circumstances of biological destructions

Experience in Spain is that wooden poles can be lacking in preservation due to a poor initial creosoting process or to the loss of the antiseptic power of creosote due to time in service.

Moreover, as time goes on, and even with a proper initial creosoting process, the fungicide power of creosote decreases. The unearthing of the pole by rainwater or surface running water added to a complex process of chemical combination of the components of creosote with the substances present in the soil and wood produce a loss of antiseptic power, and fungal growth appears in the outside surface; the rot progresses producing outside destruction that can become a major problem.

It is common to find inside and outside destruction simultaneously at a given time. An attack starts outside, in the weak points, or an external attack progresses to a poorly preserved zone inside.

The danger encountered due to the diminishing antiseptic power of creosote leads to the need for periodic inspections of poles, once the effectiveness period of creosote has expired.

Usually, it can be considered that the preservative action of creosote begins to be diminished below its threshold, after the pole has been in service for about 10 years, even though various circumstances may make it advisable to extend or reduce this period.

In a planted pole, optimum conditions of humidity, ventilation, temperature and sunlight for the development of the infection generally concur in the surroundings of the insertion area.

Therefore, for the evaluation of a fungal attack in a pole, and for a new wood preservation, action should be taken, specially, and with no exception, in the insertion area, resulting in the need for unearthing in the region from the earth line and 40 cm underneath it.

The upper zone, adjacent to the insertion area, up to 50 cm above the earth line, is also very vulnerable, and sometimes, due to the variability of life conditions and wood characteristics, fungi attacks may occur up to 2 m above embedment. This must be taken into account when inspecting and treating the poles.

The top of the poles, sometimes, show cavities produced by some species of birds (woodpeckers), which sometimes completely perforate the pole horizontally and, in other cases, vertically communicating with cavities located at different heights. These destructions often start in unoccupied holes for bolts. Usually, the attacks produced by birds take place in the lines crossing high mountain regions. The intensity of the attacks varies from emerging attacks, to the total drilling mentioned above.

I.3 Aspect of attacked wood

In the majority of cases, in the attacked wood areas, there can be loss of consistency or total disappearance of the wood fibres, resulting in clean cavities, sponge cavities, or dense insect galleries. In all cases, the residual wood fibres have lost their quality as mechanical strength support.

The previous discussion of the mechanism through which destructive wood agents produce their effects inside and outside poles, together with theoretical considerations, leads to the following aspects of practical value.

An internal cavity can appear that is between the external layer and the generally better preserved resinous heart. This conserves some wall thickness and typically the attacked area progresses in an annular region. This is schematically shown in Figures I.1 and I.2.

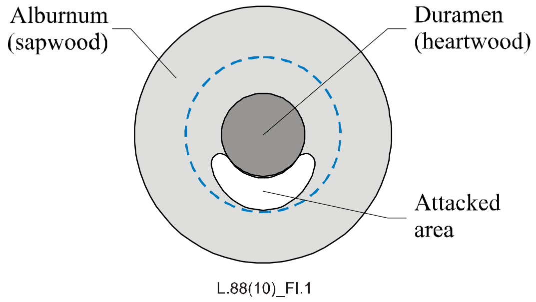

Figure I.1

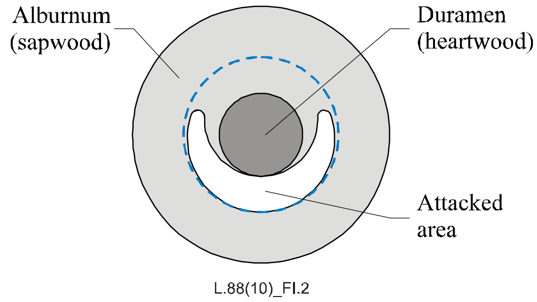

Figure I.2

There are two extreme cases, a complete circular ring (see Figure I.3) and a hollow pole (see Figure I.4) that preserve an external, wood column.

In the former case, the internal resinous framework is preserved; while in the latter case, it is not.

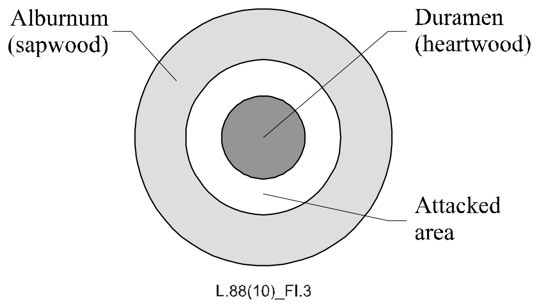

Figure I.3

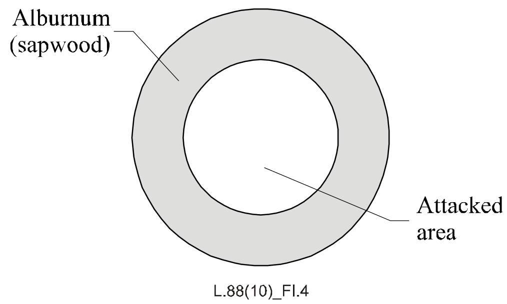

Figure I.4

When the efficiency of the creosote is diminished in a zone of the surface of a pole, the rotting advances towards the inside creating a visible cavity (see Figure I.5), which in more advanced cases can reach the duramen (see Figure I.6).

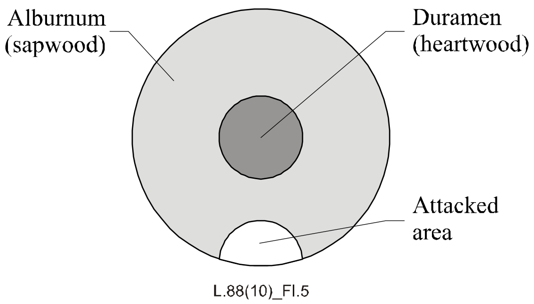

Figure I.5

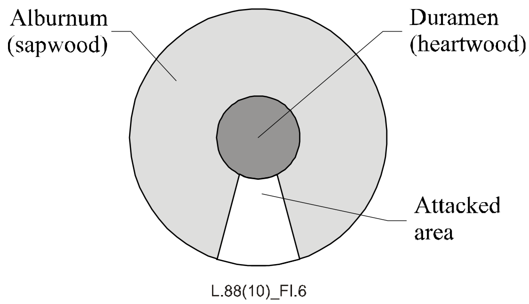

Figure I.6

Sometimes, the decrease of the preservation concerns the whole contour of the pole and then, more than a cavity, a rotting of the external wood appears, characterized by a transformation in a soft or spongy easily separable wood with an adze; this kind of destruction can be named external attack in crown (see Figure I.7).

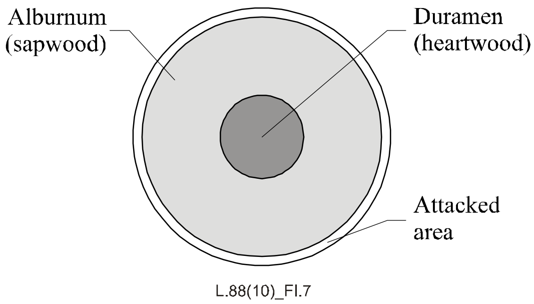

Figure I.7

The previously exposed cases can appear individually or simultaneously; some examples are given in Figures I.8, I.9, I.10 and I.11.

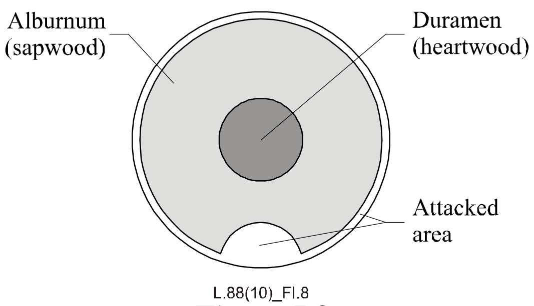

Figure I.8

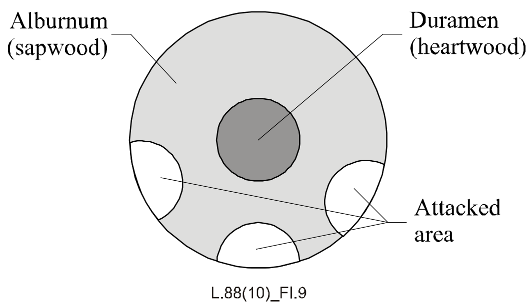

Figure I.9

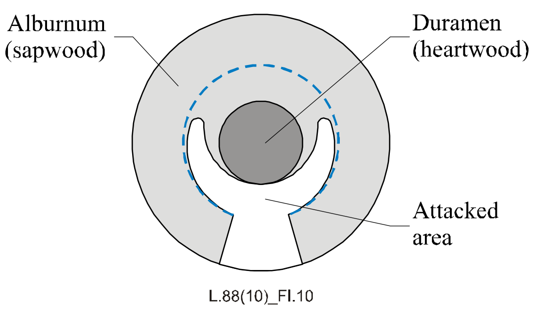

Figure I.10

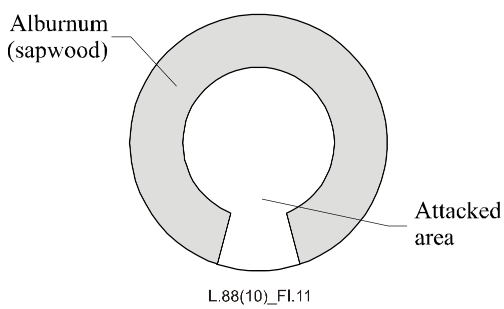

Figure I.11

Appendix II

The Korean experience for identifying concrete pole's foundation

(This appendix does not form an integral part of this Recommendation)

II.1 Testing program

Full-scale poles have been planted into the ground to confirm that the 1st peak of resonance frequency is dependent upon the pole's foundation strength. A spun-cast prestressed concrete pole was used which is 7 m long. Poles were embedded with sand, crushed stone, and concrete as back-fill, as shown in Figure II.1. Figure II.2 shows an accelerometer mounted at the side of pole, which has 0.15 to 1 kHz frequency range. In this test, D, H_1, and H_2 were 1.2 m, 1.2 m, and 2.0 m, respectively.

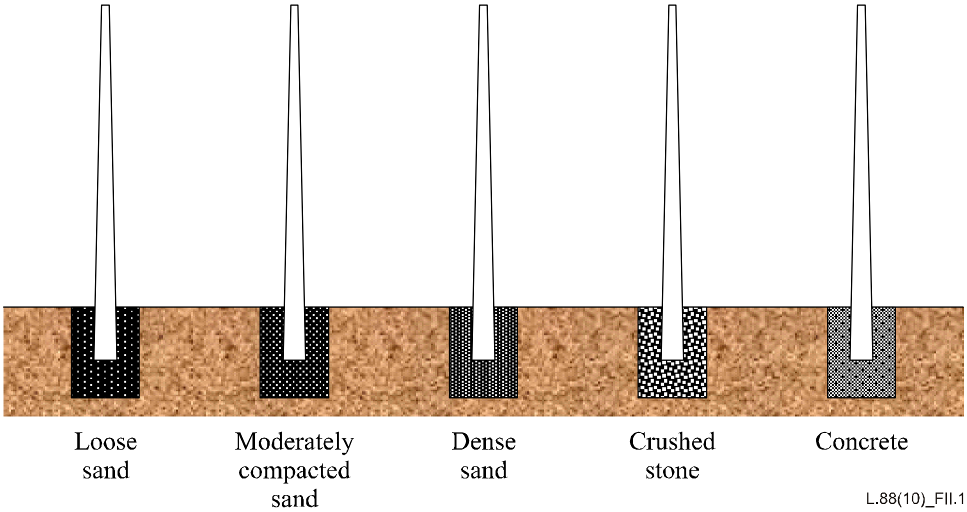

Figure II.1 – Tested poles

Figure II.2 – Accelerometer used in the test

II.2 First peak resonance frequencies

A series of field tests to obtain the resonance frequencies was performed. Figure II.3 shows typical vibration waveform and frequency spectrum for a loose sand and concrete foundation.

a) b)

Figure II.3 – Typical waveforms and spectrums; a) loose sand; b) concrete

The 1st peak resonance frequencies for tested poles are presented in Table II.1.

Table II.1 – Resonance frequencies

Backfill materials	Degree of compaction	Field relative density (t/m^3)	1st peak (kHz)	2nd peak (kHz)
Sand	Loose	1.496	1.5	13.5
	Moderate	1.588	2.0	14.5
	Dense	1.654	4.0	17.0
Crushed stone	–	N.A	4.0	17.5
Concrete	–	N.A	4.0	18.5

II.3 Discussions

It is found that the 1st peak resonance frequency is closely related to the pole's foundation strength. If the 1st peak resonance frequency is determined as a reference value, we can identify and evaluate unknown pole foundation quantitatively by comparing the 1st peaks.

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Printed in Switzerland
Geneva, 2011