CEMENT RESEARCH INSTITUTE OF INDIA

CRI TECHNOLOGY DIGEST

CONCRETE POLES

June 1982

CONCRETE POLES

1. INTRODUCTION

For many years, poles made of wood, steel and concrete have been in use in providing support for street lighting, telephone, telegraph and power transmission lines. Prestressed concrete has been used extensively for poles in different countries. In India, many State Electricity Boards have already switched over to the use of prestressed concrete poles for rural electrification programmes. Recent estimates place the annual requirement of poles for rural electrification between 2 to 4 millions. Although, prestressed concrete poles are being increasingly used on low voltage lines, these have yet to be used for high voltage power transmission lines, in India. Also, the use of concrete poles by others, like Railways and Post & Telegraphs have not made much impact, although they can be potentially large users.

A pole is a simple structural element in prestressed concrete design. Because of this and also the determinate state of stresses in the pole, design and connected problems are often treated as elementary. Howsoever simple it may look like, it has enough potentials as a manufactured concrete product. The design and manufacture cover a very large number of similar units of more or less the same shape and pattern; in fact, many identical units are made in mass production of poles. Therefore, any improvement in the design and manufacturing process will result in substantial savings. In view of this, CRI has made systematic studies to improve the design and production of concrete poles.

This Technology Digest briefly highlights the work done by CRI towards development of economical design and standardization of concrete poles for a variety of usages.

2. ECONOMIC POTENTIAL AND SIGNIFICANCE

As mentioned above, the annual requirement of poles for rural electrification is between 2 to 4 million. Taking the average cost of a prestressed concrete pole to be Rs 200/- and assuming 10% savings in cost as a result of standardization and economical design, it can be seen that there will be a saving of Rs 20/- per pole, resulting in a net *annual saving of Rs 40 million*, on a conservative estimate. In fact, as mentioned during the Ninth Standardization Conference of Rural Electrification Corporation held in New Delhi in 1981, CRI poles were reputed to be cheaper than the conventional poles by as much as Rs 50/-.

3. TYPES OF POLES

3.1 Shape of Poles

The shape of the cross-section of concrete poles is important in design, since this would influence several factors like proper utilization

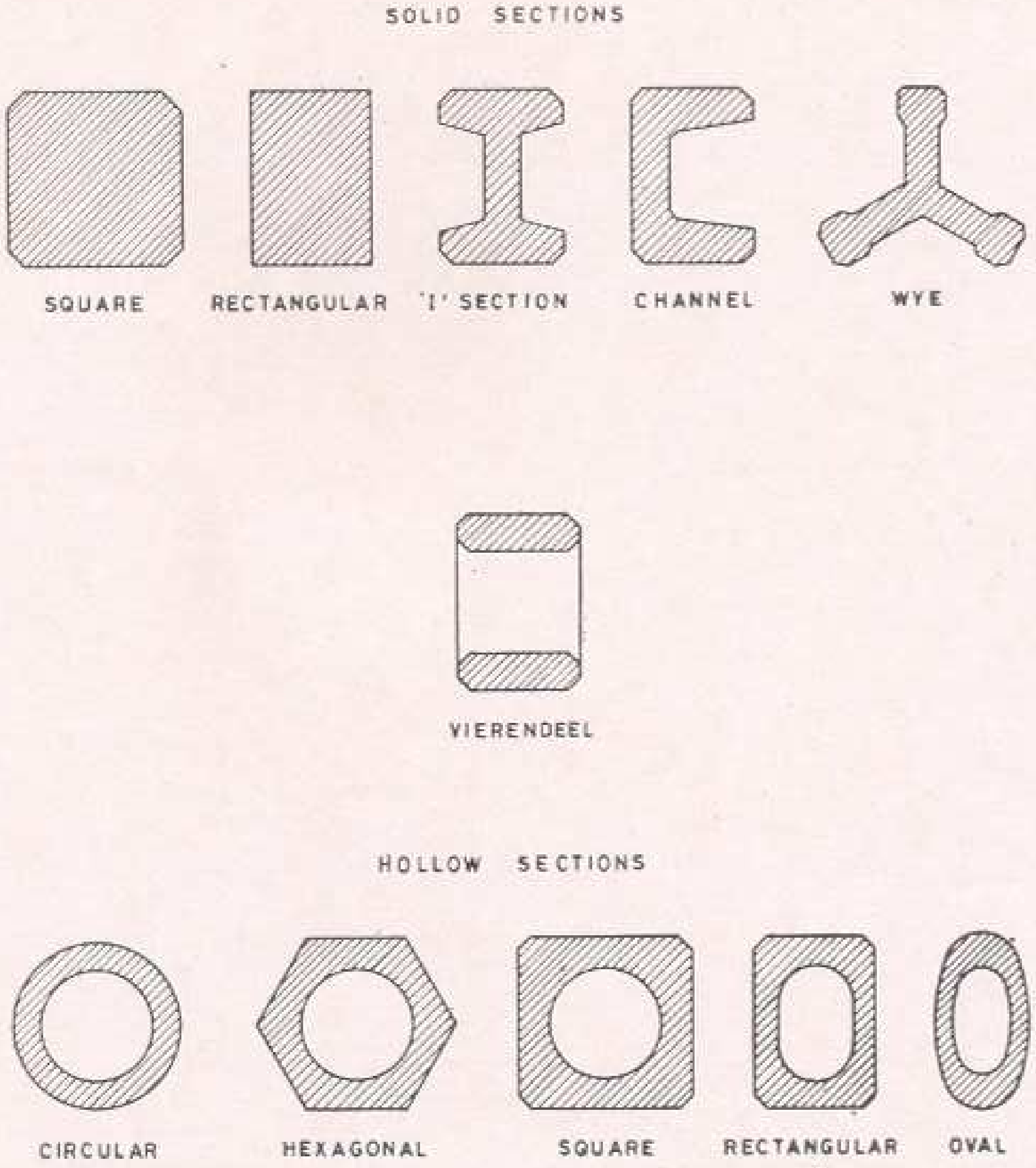

Fig 1 Shapes of poles

of the material to their full strength, facilitating pretensioning of steel, cost of the moulds, space requirements in transportation and aesthetics. Cross-sectional shapes which are in use in various countries are shown in Figure 1. Some of the more common shapes among these are: (i) solid rectangular, (ii) vierendeel, and (iii) circular hollow section. Studies have been made on these types in CRI.

3.2 Design Principles

A) Solid Rectangular Poles—Prestressed concrete poles of solid rectangular type are designed considering both serviceability and safety (strength). For a specified factor of safety and a given concrete grade, a particular type of pole is designed as follows : First, a wire diameter is chosen. Then, various possible configurations (arrangements) of wires are decided, for different number of wires (even numbers only), starting with a minimum value of 8 and maximum of, say, 20. Figure 2 gives typical wire configurations for 12 and 16 number of wires. For a particular configuration of wires, the minimum possible permissible breadth of pole is determined. The depth of pole cross-section is determined at ground level limiting the compressive and the tensile stresses, developed in the extreme fibres of the cross-section under the action of the average permanent load (taken equal to forty percent of the working load)and the first crack load (taken equal to the working load), to their respective permissible values.

B) Vierendeel Poles—As in the case of solid rectangular poles, these poles are also designed from the considerations of serviceability and strength. The design is carried out in a manner similar to that of solid rectangular poles. The design procedure for prestressed concrete vierendeel poles is based on the assumption that the two mullions (uprights) behave as an integral part of a single cantilever, predominently under bending action. The number of windows in the vierendeel poles is determined, using this assumption, which is achieved by checking the degree of coupling between the two mullions. The degree of coupling, in turn, depends on the depth of transom (horizontal member), depth of window, thickness of mullion and other cross-sectional dimensions of the pole.

C) Circular Spun Poles—In these poles, the cross-section of the pole is circular, and has prestressing wires distributed all round the periphery, which makes it difficult to adopt any simplified formula. For determining the ultimate moment capacity of such a cross-section,

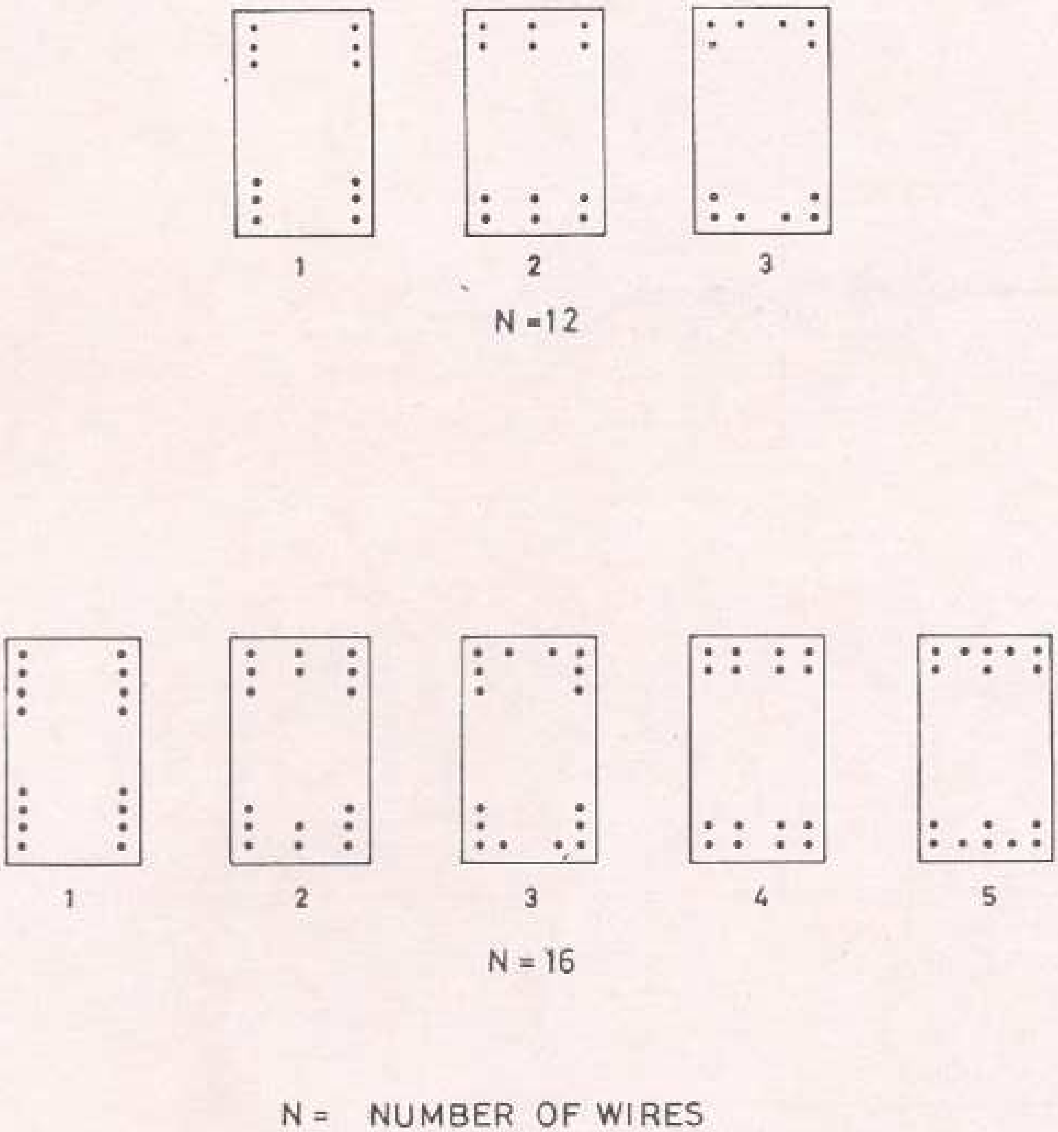

Fig 2 Typical wires configuration

the moment of all forces (compressive force in concrete and tensile force in prestressing steel) is taken about the neutral axis. The position of the neutral axis is determined by equating the compressive force in concrete and prestressing steel in the compression zone with the tensile forces in the prestressing steel in the tensile zone in the cross-section of the pole. Determination of the position of the netural axis is a trial and readjustment procedure. It may require a number of trials before arriving at a reasonably correct value of the neutral axis. The cross-section of the pole is also checked under working and average permanent moments (40 percent of working moments) by limiting the compressive and tensile stress in concrete to their permissible values.

4. WHAT CRI HAS ACCOMPLISHED

4.1 Design

During the last few years, CRI has successfully completed a number of projects related to the development of economical design of concrete poles. Some of them relate to: (1) Development of economical (minimum cost) designs for prestressed concrete and reinforced concrete solid rectangular poles for 11 KV and LT lines, sponsored by M/s Rural Electrification Corporation Limited; (2) Development of designs for tangent location, using tor-steel (grades 42 and 50), sponsored by M/s Tor-Istig Corporation of India; (3) Development of least weight designs for prestressed concrete solid rectangular poles for 11 KV lines for tangent location sponsored by Kerala State Electricity Board; (4) Development of economical designs for prestressed concrete solid rectangular and vierendeel types of poles for 33 KV lines sponsored by M/s Rural Electrification Corporation Ltd; (5) Development of designs for prestressed concrete circular spun poles for 110 KV and 220 KV transmission lines, sponsored by M/s Water and Power Consultancy Services (India) Ltd (WAPCOS). Table 1

TABLE 1 QUANTITIES OF MATERIAL FOR TYPICAL PRESTRESSED CONCRETE POLES

Type of Poles	Quantity of Concrete Required cu m	Quantity of Prestressing Steel Required Kg	Weight Kg
Solid Rectangular Pole (11 KV Line) 8·0 m Length/200 kg working load	0·158	7·85	380
Vierendeel Pole (33 KV Line) 9·0 m Length/400 kg Working Load	0·267	13·08	640
Circular Spun Pole (110 KV Line) 18·0 m Length/215 kg Working Load	2·300	145·00	5500

indicates quantities of materials required for typical poles for 11 KV, 33 KV and 110 KV transmission lines. The design for solid rectangular as well as vierendeel type of poles were verified by testing over 200 prototype pole specimens as per IS : 1678 "Specifications for Prestressed Concrete Poles for Overhead Power Traction and Tele-Communication Lines". Figure 3 shows a typical pole under load testing. The total cost of a pole after it is erected in its final position will depend on the cost of materials used, its manufacture, transport and erection. The cost of some of these items would in turn depend, to some extent, on the design itself.

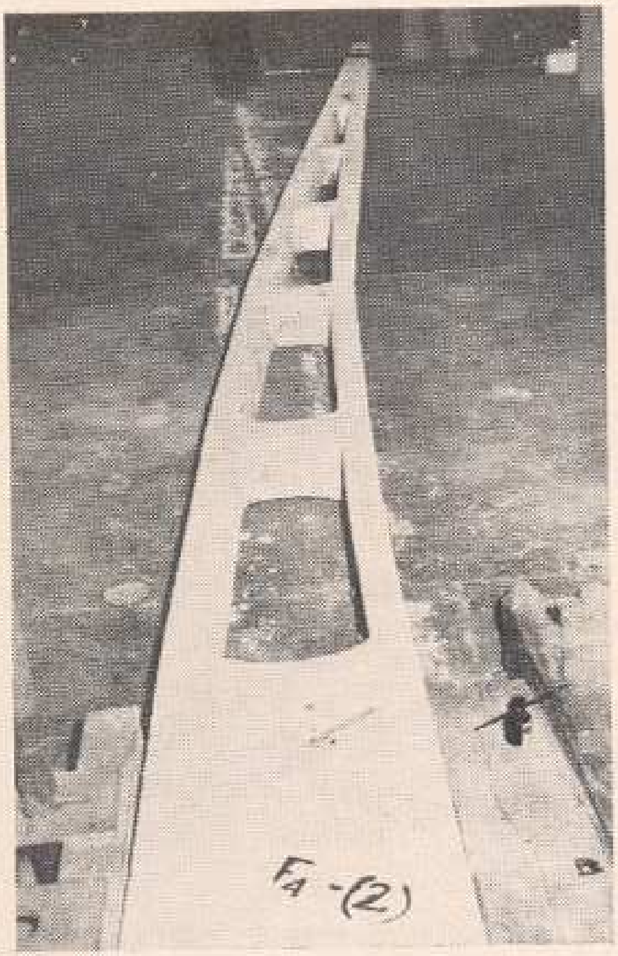

Fig 3 Typical pole under load test

4.2 Standardization

The developmental work on concrete poles has led to the revision of the Indian Standards Specification on Prestressed Concrete Poles (IS : 1678). This revised version (IS : 1678-1978) is based on the work carried out by CRI. Some of the new design concepts introduced in the specification include : (i) Average permanent load (taken as 40 percent of the working load acting on the pole) and (ii) hypothetical flexural tensile stress of concrete (this is the tensile stress of concrete on flexural members, for a crack width of 0·1 mm). The specification also now permits the use of a lower factor of safety (from 2·5 to 2·0), which in turn, can lead to further savings of the order of 10 percent. Also, with these modifications in the specification, it is now possible to design partially prestressed concrete poles (poles using both tensioned as well as untensioned reinforcements). In addition to IS : 1678-1978, CRI has also actively contributed towards preparation of REC manuals on prestressed Concrete Poles, which cover both design as well as manufacturing aspects.

5. CRI EXPERTISE

Necessary expertise is available in CRI for dealing with developmental work connected with concrete poles and transmission towers. Computer programmes are available with CRI for evolving economical designs. In addition, CRI possesses a 1-metre wide and 35 metre long prestressing bed, with bulkheads having a load capacity of 50 tonnes. Provision exists on the Heavy test floor for testing prototype pole specimens both in horizontal as well as vertical directions.

Prepared by : Dr N Raghavendra & Shri H K Julka
Edited by : Shri S K Khanna

Published by Shri S K Khanna on behalf of Cement Research Institute of India, M 10 South Extension II, New Delhi 110 049 and Printed at Indraprastha Press (CBT), Nehru House, New Delhi 110 002