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**Design of High Masts Needing no Maintenance**  
Projet de mâts élevés ne nécessitant aucun entretien  
Projektierung von unterhaltungsfreien hohen Masten

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#### SUMMARY

It is not very often you are faced with requirements of structures which need no maintenance for 50 years. However, when it is a question of a new transmitter network for the Danish television comprising twelve 300 m high masts a serious effort is made. Planning and design of these masts ensure such a durability. The article describes structures, choice of material and protection against corrosion as well as the databased information system which records all information on the masts and antennas from fabrication and through the whole operation phase.

#### RÉSUMÉ

Des conditions qui comportent une durée de vie de cinq décennies sans entretien sont peu ordinaires pour les structures. Cependant lorsqu'il s'agit d'un nouveau réseau de télévision de 12 mâts, chacun d'une hauteur de 300 m, de telles exigences sont à l'ordre du jour. La planification et la conception des mâts pour la nouvelle chaîne de télévision danoise, assure une telle durée de vie. L'article traite des structures, du choix des matériaux et de la protection contre la corrosion, ainsi que du système d'informations informatisé, qui enregistre l'ensemble des données relatives au réseau, depuis la fabrication et pendant toute la phase d'exploitation.

#### ZUSAMMENFASSUNG

Eine Forderung, dass Konstruktionen 50 Jahre lang unterhaltungsfrei bleiben, ist nicht alltäglich. Handelt es sich indessen um ein neues Fernsehmastennetz von zwölf 300 m hohen Masten, wird eine ganz ausserordentliche Leistung erforderlich. Planung und Projektierung der neuen dänischen Fernsehmasten sichern eine solche Dauerhaftigkeit. Der Artikel beschreibt Konstruktionen, Wahl von Materialien und Korrosionsschutz sowie das databasebasierte Informationssystem, das alle die Anlagen betreffenden Bedingungen — von der Fabrikation durch die ganze Betriebsphase hindurch — registriert.



## 1. INTRODUCTION

In 1986 the Danish Government enacted a law for the establishment of a transmitter net-work for a second national television channel. The net-work is being established from 1987 to 1989.

In the planning, design and fabrication of the supporting steel structures the stringent precautions have been payed to long durability. Moreover it has been the aim to design masts which were easy to inspect and needed practically no maintenance.

Due to the requirements of high reliability great importance has been attached to the durability. At the same time it has been possible to keep the construction costs and the maintenance costs at a minimum.

The Danish Teleadministrations has awarded the contract for the detailed design of the structural works to the consulting engineers Rambøll & Hannemann.

## 2. DESCRIPTION OF THE PROJECT

The new transmission net comprises 12 new stations, each with a 300 m high mast carrying the TV 2 antenna.

The overall application of round bars makes the form of the very high masts remarkable. The structure is simple and appears on the whole light and elegant. Furthermore we have designed a structure which needs practically no maintenance and at the same time introduced the World's best guys. All details have been carefully analysed to maximize the structure to fulfil all requirements with regard to function (static, dynamic and access), fabrication, erection and maintenance.

## 3. FUNCTIONAL REQUIREMENTS

The basic requirements to function of the masts are simple :

- The UHF-antenna supported inside a 18 m high glass-reinforced plastic cylinder, 1.6 m in diameter shall be placed 300 m above ground.
- A hoist for 3 persons/500 kg shall run from bottom to top.
- A ladder with safety cage shall be installed from base to top.
- Various antennas may be installed all over the mast.
- Besides the 2x5 inches feeders for the UHF-antenna, cables, feeders, wave-guides, etc. will be needed for the other antennae.
- Easy and safe conditions for working in the mast must be fulfilled.
- The masts shall be able to withstand a rupture of one guy.

The economical requirements are even more simple :

- The total construction costs shall be the lowest possible, and
- The maintenance costs shall be the lowest possible

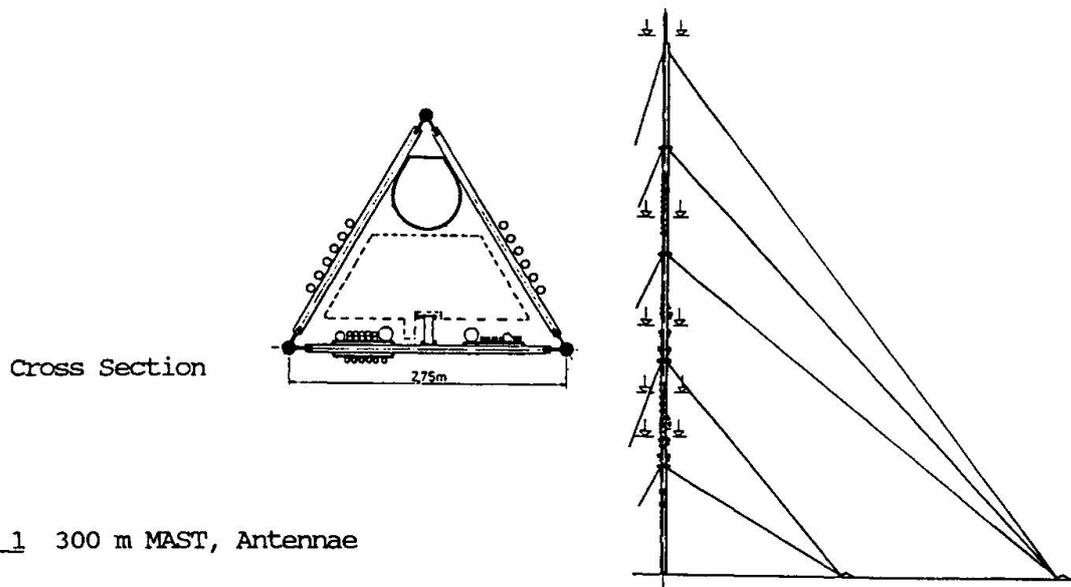


Fig. 1 300 m MAST, Antennae

#### 4. STRUCTURAL OUTLINE

The latticed mast has a triangular cross-section with a face width of 2.75 m to the top. It is guyed in three directions at five levels, and the base is pinned to the mast foundation. A continuous ladder with backguards is placed inside the cross section. If you don't feel like climbing the 1000 steps, you can use the diesel-hydraulic hoist, which runs inside the cross section and may be stopped at arbitrary levels. From the working platform on top of the hoist installation and inspection works may be undertaken.

The leg members are solid rounds with a diameter of 150 mm from base to top.

The diagonals in the V-bracing are solid rounds with a diameter of 85 mm. At the bottom 150 m of the shaft horizontals reduce the buckling length of the legs.

The guy ropes are spiral stands. The diameter of the guys is 43 mm except for the second lowest set, where the diameter is 55 mm.

#### 5. DURABILITY OF THE MAST

When planning and designing the mast special attention is paid to maximize the protection against corrosion, so that the masts need no maintenance for a period of at least 50 years.

We decided on a latticed mast of round bars as the best solution :

- The surface of the structural steel-work is smooth and has been reduced compared to other steel sections. Therefore there is no collection of dirt or moisture anywhere or risk of condensates as e.g. is the case in tubes.
- The guys and their attachments have been subject to careful analysis, one of the reasons being the various collapses due to guy ruptures and break of the guy attachment.
- Wind loads on the mast are reduced to a minimum and the mast is at the same time dynamically completely stable.



## 6. PROTECTION AGAINST CORROSION

Maintenance of the surface treatment of guyed masts to ensure proper protection against corrosion is extremely expensive. It is very often necessary after some years to clean, sandblast and paint the masts. Maintenance of guy ropes is extremely difficult and replacement of worn-out guys is often the best solution. Therefore special attention is paid to the surface treatment and choice of material.

All structural steel-work is hot-dip galvanized with a heavy layer of zinc. A minimum thickness of 250 microns (approximately  $1800 \text{ g/m}^2$ ) is achieved by specification of the chemical composition of the steel and the dipping time in the zinc bath. Painting is avoided. The ladder with backguards, cable ladders, bolts, nuts, clamps etc. are made of stainless steel. Thus the mast needs no maintenance for a period of at least 50 years in normal aggressive surroundings.

The problem left is the guy ropes. Stainless steel wires are too expensive. Until a few years ago the only available solution was hot-dipped galvanized steel wires with a rather thin (approx.  $300 \text{ g/m}^2$ ) cover of zinc. Recently heavy galvanized wires - approx.  $600 \text{ g/m}^2$  - were available at reasonable prices. With a lifetime of 25-40 years such guys are almost satisfactory and have been used in Denmark for 5-6 years.

The guy ropes for the 300 m masts have an even better protection. The wires are hot dipped in an alloy of 95% zinc and 5% aluminium resulting in a cover of  $400 \text{ g/m}^2$ . This alloy "GALFAN" is at least 2-3 times more effective than pure zinc. Furthermore during the stranding the individual wires are layed in a special compound, "NYROSTEN", to ensure that the finished rope is without any hollow parts. After the stranding the whole surface of the rope is covered with the same compound. Various tests are undertaken during the fabrication of the thickness and adhesion of the surface treatment. It is expected that the lifetime of these guys is 40-60 years.

The guys for the new 300 m masts are the first of this type in the World and definitely quite outstanding. It is to be mentioned that the technical specifications as well as the demands on surface treatment were set up by Rambøll & Hannemann. This new design has literally contributed to raising the level of the quality of the guys and at competitive prices.

Also the diesel hydraulic hoist is designed to have a maximum life time. The cabin is made of stainless steel plates and the working platform on top of the cabin is of aluminium.

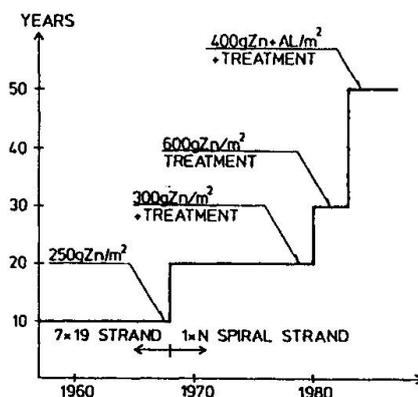


Fig. 2 Lifetime of Guy Ropes



As an extra security the structure is analysed for the dynamic forces immediately after one guy suddenly breaks due to unforeseeable stresses or errors.

#### 7. FUTURE INSPECTION

The antennas in the 300 m masts is such a vital part of the national communication system and reliability is a must. Therefore systematic inspections with intervals of 3-5 years are carried out.

In the new 300 m masts inspection work is easy and quick.

First access to the mast is extremely favourable. From the platform on the hoist almost everything in the mast can be inspected, as the hoist can be stopped at arbitrary levels. The guys can be inspected from a manned chair which can be drawn up and down the guy.

Second very few irregularities will occur, as normally no maintenance is necessary.

#### 8. COMPUTERIZED INFORMATION SYSTEM

A data based information system has been developed to secure that all useful and updated information on the masts and antennas is systematically registered and stored safely and well-planned in a computer.

The information includes e.g.:

- Basis and design data
- Control reports and inspection data from the fabrication phase
- All registrations from the regular inspection work and operation phase
- Maintenance work, if any, or alterations of structure.
- Information with exact detail drawings of all antennas and cables in the mast

In the operation phase the information system ensures a safe and efficient maintenance work, e.g. the computer tool quickly produces a view of similar elements in all the masts (antennas, cables, connections etc.) if an inspection on one location shows that special attention is demanded.

Also the system makes it possible regularly to analyse loads and structures if changes are wanted and thereby fully secure the durability aimed at.

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