OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

RESTRICTED

DP/ID/SER.A/ 1362
26 June 1990
ORIGINAL: ENGLISH

18449

INDUSTRIAL ADVISORY SERVICES AND TRAINING

DP/EGY/88/032

EGYPT

Technical report: Recommendations for Tower Testing Stations*

Prepared for the Government of Egypt
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of L. Engsbro and J. Hastrup,
Consultants in design of electrical tower testing stations

Substantive officer: Mr. Gürkök
Engineering Industries Branch

Backstopping officer: Mr. Koliakine
Section for Integrated Industrial Projects

United Nations Industrial Development Organization
Vienna

----

* Mention of company names and commercial products does not imply the endorsement of UNIDO. This document has not been edited.

V.90-86012

Table of Contents

ANNEXES

1. INTRODUCTION

This report has been prepared for UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION (UNIDO) by

- Lars Engsbro, M.Sc.C. & S. Eng., Manager
- Jeppe Hastrup, M.Sc.M.E., Ph.D.

both engaged by Danish Power Consult A-S and appointed as experts by UNIDO.

1.1 Scope of Work

The scope of work was laid down in the job descriptions for the experts as mentioned below.

The two job descriptions, however, should be read in conjunction with each other. In brief, it could be mentioned that Mr Engsbro is an expert on design of high voltage towers, and Mr Hastrup is an expert on the field of instrumentation and computer installation.

Post DP/EGY/88/032/11-63:

(1) Appraise himself of the types of design of electric towers for overhead transmission lines which are produced locally or imported to Egypt, for overhead transmission of 66, 220 and 500 kV.

(2) Provide recommendation on the most appropriate design and technical specifications of an electrical tower testing station required for mechanical testing of various electric tower prototypes. The testing station will be utilized for applying to electrical towers transverse, longitudinal and vertical loads up to destruction level and measuring of bending and torsional moments and shear of the electrical tower construction as well as transferal and longitudinal deflections.

(3) Advise on equipping the testing station with all necessary measuring instruments and accessories.

Furthermore, the expert will be expected to prepare a final report, setting out the findings of his mission and recommendations to the Government on further action which might be taken.

Post DP/EGY/88/032/11-60:

(1) Studies of the existing tower design, the calculation and manufacturing methods normally used by Metalco Company.

(2) Existing level of computer technique applications in the Metalco Company. Inquiry on the policies for data processing and facilities for measuring and documentation of data.

(3) Inspection of the proposed site for the tower testing station and the available facilities for operation of the plant.

(4) Examination and discussion of design and testing criteria for steel towers for the actual voltage levels 66 to 500 kV, especially the criteria used by the Egyptian Electricity Authority, EEA.

(5) Discussion with Metalco on prospective number of testing to be carried out on H.V. towers and the possible development in adjacent fields, i.e. towers for telecommunication, public lighting, etc.

(6) Based on the findings as above and the discussions with Metalco the team of experts will make a draft recommendation and specification of the testing station.

(7) Furthermore, the expert will be expected to prepare together with expert 11-63 a final report including the findings of the mission as above indicated, and the mechanical feasibility of the testing station. The report will describe the recommendations and technical specifications as detailed below:

- Conceptual layout of the plant with rack structures, foundation pad, erection space and equipment, mechanical equipment for testing.
- Capacity and mechanical loads of the station.
- Housing facilities for instruments and staff.
- Proposal for cabling, measuring and reading instruments.
- Proposal for computer hardware and software installation for the testing station.
- Proposal for the operation of the plant.

1.2 Background Information

The background information for the experts was summarized in the job description as given below:

Metalco is a public sector company affiliated to the Ministry of Industry which was established in 1968 and is responsible for local manufacture of steel structures, currently the main products are steel frames for factories, buildings, tanks, and equipment, as well as production of steel towers for transmission lines, 33, 66, 220, 500 kV for the Ministry of Electricity.

Metalco is the main supplier in Egypt which manufactures such steel towers, and has modified the current factories using CNC M/C's (computerized numerical control machines) with a total investment of about 10 million Egyptian pounds in order to manufacture and supply such steel towers and provide the design office with computers enabling them to improve and increase.

The international specification of steel towers requires the designer and manufacturer to undertake loading and destructive tests to ensure that the design fulfils all the actual loads.

Such tests are carried out in a tower testing station. (Not available in all countries). In order to accept the steel towers according to international specifications, the Ministry of Electricity requests Metalco (as a supplier) to proceed with the said tests. Currently the testing operations are carried out through international testing stations which are capable of undertaking these tests.

The strategy is to design, manufacture and test the steel towers for transmission lines, 33, 66, 220, 500 kV, locally in order to prevent sending the towers abroad for testing purposes, and hence improve the balance of payments.

1.3 Reading Instructions

This report is divided into seven sections.

Sections 1 and 3 contain some general information and a report on the appraisal mission, whereas section 4 covers the bases of design and the factual conditions to be considered in connection with the experts' concept for layout and instrumentation of the testing station.

Section 2 gives a brief summary and the experts' recommendations for the tower testing station.

Section 5 gives a description and the specifications of the actual testing station. All works and a working programme for the station are defined.

In sections 6 and 7 the overall budgets and the time schedule are outlined.

The numbering of annexes follows the sections as mentioned above. Here, especially the UNDP report should be referred to.

1.4 Definitions

Throughout this report the terminology is defined as follows:

Client The power company who asks for or requires a tower test and therefore also defines the testing specifications.

Consultant The designer of the testing station and the responsible body for the correct function of the station.

Contractor The person whose tender has been accepted by the Employer and therefore executes the work. The Contractor may also be called Supplier or Subcontractor, as appropriate.

Employer The owner of the testing station and the body who orders the construction of the station.

Experts The authors of the present report.

1.5 Acknowledgement

The experts wish to thank all their contacts for the help and the information given during the appraisal mission in Cairo, and also especially the management of Metalco for kind hospitality and discussions about the testing station.

2. CONCLUSIONS

2.1 Summary

Metalco, being the main supplier of high voltage towers in Egypt, wishes to construct a tower testing station to continue the development over the last few years in the field of production of steel lattice towers.

High voltage towers are requested by the clients to be subjected to full-scale testing before final approval of the design, and before production.

For recommendation of an appropriate layout and instrumentation of a testing station in Egypt for high voltage towers in the range of 66 to 500 kV two experts were appointed for the job by UNIDO, and an appraisal mission took place in January 1990.

During the mission in Cairo a preliminary report on Bases of Design was made by the experts and agreed on with Metalco at a meeting on January 15. The present report is an elaboration and detailing of the preliminary report.

The proposed site for the station is situated next to the Steelco factory at Helwan 30 km south of Cairo. The site is approximately 95 x 175 m.

The primary base for the station as regards tower geometry and mechanical loads will be the 220 kV double circuit and the 500 kV single circuit designs according to the specifications of EEA. Necessary considerations as to designs applied abroad, however, are also to be considered.

The main characteristics of the station are recommended to be a 400 kN pull for the conductors, 16 x 16 m tower base and tower heights up to 54 m.

The station will be equipped with 32 winches.

The measuring equipment will consist of dynamometers for measuring of the pulling forces, a total station for optical measuring of deflections, and a weather station.

The recommended computer system will be a PLC for controlling the winches during the test, and an interconnected PC for data logging and reporting.

A control building of 100 m² applies.

The future works are divided into three groups:

(1) Design and specifications by a Consultant,
(2) Local works to be undertaken by the Employer, and
(3) Supplies of equipment and computers from abroad.

The estimated costs amount to approx. 260,000 US$, 1,870,000 £E, and 930,000 US$, respectively. (The rate of exchange is 1 US$ to 2.6 £E).

The overall time for completion of the station is estimated at 21 months from the commencement date of the Consultant's work.

Finally, the training recommended for the staff within the first year of operation is briefly described.

2.2 Recommendations

The findings of the appraisal mission and the technical considerations for the testing station are described in sections 3 and 4.

Based on these matters the specifications and the future works for an appropriate layout and instrumentation of the station are outlined in section 5 with pertaining annexes.

When opening the final meeting during the appraisal mission the chairman of Metalco, Mr. Fouad Soliman, stated that Metalco wishes to proceed with the testing station project.

The experts conclude that such a station will be technically feasible as regards structures, instrumentation, and construction of the plant.

Strategy and economic considerations are out of the scope of the present report, but are discussed in the UNDP Report in Annex 1.1.

3. APPRAISAL MISSION

3.1 Report on Meetings and Visits

A brief description of the appraisal mission carried out is given below:

Date	Place	Contacts	Topics
Jan 8	UNDP Cairo (1)	Mr T. Sabry Senior Officer	Introduction
	Metalco Cairo (2)	Mr Ahmed Fouad Soliman Chairman Mr Hosam El-Din Helal Tech. Manager Mr Yussef Bottros Planning Sector Manager	Introduction, developments within design and production of steel towers. Basic requirements of the testing station. Tower testing until now (abroad). Design and detailing. Data processing, computer software and hardware. Prospectives within tower testing. Planning of visits and meetings.
Jan 9	Metalco, Mezzalat Factory	Mr Yussef Bottros	Inspection of the factory including CNC-lines and assembly test of steel tower. Erection crane available.
	Steelco, Halwan	Mr Farouk Mousa General Manager	Inspection of the CNC-lines and the proposed site.

Date	Place	Contacts	Topics
Jan 10	UNDP	Mr Sabry	Intermediate reporting.
	EEA, Cairo (3)	Mr Ibrahim Nawara Managing Director of network projects Dr Mohamed M. Awad Managing Director of Research & Studies	Introduction. Tower types, layouts, design criteria, loads, conductors. Testing specifications and requirements. EEA's high voltage laboratory and plans for a tower testing station.
	Metalco	Mr Hosam El-Din Helal Mr Youssef Bottros	Working programme for the testing station.
Jan 11	Metalco, Cairo	Mr Youssef Bottros	Principles of testing and operation. Layout of the testing station. Mechanical equipment. Optical measuring equipment. Computer system. Staff for operation.
	Centech, Cairo (4)	Ms Nadine Bibawi	Maintenance of computer systems. Contract services.
Jan 13	Research Centre, Cairo (5)	Dr Monir M. Kamal Dr Amira Abdel Rahman Dr Ossama Mazen	Codes of practice for structural steel work, concrete works, and foundations as well as power installations in buildings. General soil conditions along the Nile.
Jan 14	Ministry of Industry, Cairo (6)	Dr Yusef K. Mazhar First Under-Secretary	Presentation of the experts' preliminary report. Discussion on the financial basis (Mr Sabry, Mr Hosam El-Din Helal and Mr Youssef Bottros attended the meeting).

Date	Place	Contacts	Topics
Jan 15	Metalco, Cairo	Mr Fouad Soliman Mr Hosam El-Din Helal Mr Youssef Bottros	The experts' preliminary report on Bases of Design. Discussion and agreement, minutes of meeting.
Jan 16	UNDP, Cairo	Mr Sabry	Debriefing
Jan 18	UNIDO, Vienna	Mr Koliakine Mr Gürkök	Debriefing and contents of the experts' report.

Addresses:

(1) UNDP
29 Taha Hussein Street
P.O. Box 982
Zamalek, Cairo
Tel: 341 5517, 340 6476, 341 2244
Fax: 340 2638

(2) Metalco
26 July Street
Cairo
Tel: 90 1299, 90 1026, 90 1648
Fax: 93 6799

(3) EEA
Egyptian Electricity Authority
Abbassia, Cairo

(4) Centech
6 Zakaria Rizk Street
Zamalek, Cairo
Tel: 342 0371
Fax: 342 0376

(5) Research Centre
General Organization for Housing, Building and Planning Recearch
Tahrir Street
P.O. Box 1770, Cairo
Tel: 71 1564, 71 6722, 71 6853

(6) Ministry of Industry
2 Latin America Street
Cairo
Tel: 355 3442

3.2 **Background for the Testing Station**

Based on the meetings with the management of Metalco the background for construction of a testing station could be summarized as given below.

General developments within the field of manufacturing high voltage towers have taken place in recent years in Egypt. The number of steel angles and steel grades available in Egypt has increased, production on CNC-lines in the factories at Mezzalat and Helwan has started, and static computer calculations of towers using the space truss method are now standard in the engineering office.

Clients most often require new tower designs to be subjected to a full-scale test before final approval of the design, and before production takes place.

Metalco therefore wishes to continue the above-mentioned efforts by constructing a tower testing station.

The testing station will allow Metalco to plan and proceed with the manufacturing of the steel towers without any delays in the production schedules. Their design of the towers will also be improved in general as the results of the tests are compiled. Strategy and economic considerations, including the pay-back period for such a plant, are of course of the utmost importance, but are not within the scope of the present report, and are referred to the UNDP Report in Annex 1.1.

The tower testing station will certainly strengthen the position of Metalco in respect of being a competitive supplier of steel towers. Also the general impression of Metalco as a competent supplier will be improved.

Today, orders of about 40,000 tons of steel towers are in progress, about two thirds of which are for export to Iraq. The orders concern towers in the range of 33 to 400 kV.

Metalco has now been approved to execute new designs for a suspension tower and an angle tower for a 220 kV transmission line in Egypt. This includes two tower tests abroad which are the first tests to be carried out by Metalco.

In the future Metalco expects 5 to 10 tower tests a year.

The main prospectives within transmission lines are the future interconnections to Jordan, Libya, and Africa to the south, as well as domestic lines in the Arab countries.

Other steel structures as for example antennas and lighting poles are not required to be tested by the clients. Testing of towers within other fields of application than transmission lines is therefore in general not to be expected.

3.3 Computer Applications and Maintenance Services

As a computer system should be an important part of a modern tower testing station the existing computer installations of Metalco were inspected.

At the headquarters of Metalco an ICI computer installation is used for finite element calculations of high voltage towers. The system is equipped with printer and plotter. The computer system is soon to be renewed.

At the Metalco factory at Mezzalat, CNC machines are used in the production, controlled by PLC's (Programmable Logic Controllers). The factory has at its disposal a computer system for editing PLC-programs with on-line down-load to the PLC's.

The factory also has a computer system at its disposal to be used in connection with order management. This is however at an experimental stage.

At the Steelco factory at Helwan, CNC machines are used in the production, controlled by Siemens PLC's. Maintenance of the PLC's is performed by Centech, a Siemens sole agent in Cairo.

Centech was visited. The company deals in sale and maintenance of Siemens computer equipment. Actual engineering in connection with new PLC installations is carried out in West Germany. The company cannot take on maintenance of other computer makes.

3.4 EEA's Project for a Tower Testing Station

Some years ago EEA prepared a first-stage document with technical specifications for design and construction of a tower testing station. The testing station was to be placed at the high voltage laboratory situated by the Cairo-Alexandria desert road approx. 25 km north of Cairo. A copy of this document was handed over to the experts by UNIDO before the mission.

EEA has just finished a report for the "Design and Construction Management for the Testing Station of Overhead Transmission Line Towers and Structures", mainly based on above-mentioned paper.

At the meeting at the Ministry of Industry the First Under-Secretary, Dr. Mazhar, mentioned that the efforts of the Ministries of Industry and Electricity would be combined in order to support the construction of one tower testing station only.

3.5 Egyptian Codes of Practice

Codes of practice for design and construction of steel structures, for reinforced concrete works as well as for soil mechanics and foundations are under final issuing at the moment and will be available for the design of the present project. The structural steel code will be in English, while the two others will be in Arabic.

The old codes date back to the sixties and will not provide a sufficient basis of today's engineering. There will, however, be a period when both sets of codes can be applied.

The code of practice for electrical installations in buildings was issued in 1970 and is still in force. The code is in Arabic.

3.6 Preliminary Report on Bases of Design

During the appraisal mission the experts prepared a preliminary report on Bases of Design. The present report is an extension of the preliminary report including more details.

The contents of the Bases of Design were as follows:

(1) Basic Design Criteria, 13-01-90
(2) Working Programme, 11-01-90
(3) Time Schedule, 11-01-90
(4) Preliminary Layouts of Testing Station, 13-01-90
(5) Concept for Computer and Measurement Equipment
(6) Examples of Screen Displays for Dynamometer, Resulting and Relative Forces
(7) Example of Report Layout

At the meeting at Metalco on January 15 the Bases of Design were agreed on with the comments made in the minutes of meeting. When opening the meeting the chairman, Mr Fouad Soliman, said that Metalco wishes to proceed with the testing station, and that he would have a meeting with the Minister of Industry about the project.

Note
For clarification it should be noted that in the above mentioned Bases of Design two layouts for the testing station were presented. The two principles have now been combined into one layout given in the present report.

4. BASES OF DESIGN AND FACTUAL CONDITIONS

4.1 Tower Testing

4.1.1 Philosophy of Tower Testing

In brief terms a tower test is a full-scale testing of mechanical requirements for the tower, and it gives a definite answer to the question whether the tower is capable of resisting the specified loads or not.

For the Client the test therefore represents a clear statement which does not involve much explanation or checking of calculations, details, etc.

For the tower designer the purpose of tower testing may be put into the two following items:

(1) Checking of the static model of calculations.
(2) Spotting of weak points in the structure.

Checking of the static model may especially be necessary for towers of the static indeterminate type, as for example the Y-tower, and tower bodies with reduntant horizontals, partly due to the slippage in the bolt connections. Testing is normally always recommended for these types, and procedures according to IEC 652 will apply.

Safe and reliable designs may, however, be obtained without application of tower tests for towers with a well-known distribution of member forces such as conventional self-supporting one-legged towers of the Danube or vertical type.

Weak points in the structure may be a result of member excentricities not taken into account during detailing. Gusset plates should also be calculated for the excentricity of the loads, and adequate plate thickness is to be chosen.

In addition, tower tests produce real data for the flexural and torsional stiffness of the structure, i.e. additional deflections due to bolt slippage are revealed.

Prototype tower tests do not provide an assessment of the carrying capacity of the tested type in a normal statistical sense as only one tower is tested.

Based on comprehensive tower tests during the years, however, the coefficients of variation may be expected to be in the range of 5-10%, a value also adopted by the IEC for computing of strength factors for lattice towers. This applies to towers designed according to a 'good tower practice', which for example is laid down in the codes of practice. Among others, the DIN VDE 0210 and the ECCS publication no.

39 should be mentioned. The ECCS is actually based on the valuable findings of executed tower tests. These publications give buckling curves and detailed rules for assessment of effective buckling lengths together with other structural guide lines to be followed.

Today's modern finite elements computer software provides a very good tool for calculation of member forces, and is also able to take into account the effect of bolt slippage. Calculation and necessary re-calculations of the tower may be carried out within a few days, once the tower geometry has been defined in the system. Application of such computer programs may therefore, to a certain extent, reduce the scope of tower testing in the future.

Finally, it should be noted that the cost of tower testing is not inexpensive, and, especially as regards light towers, it may be several times the cost of one tower. For construction of short lines tower testing would normally not be economically justifiable. Furthermore, such economic considerations may be extended if towers are designed and detailed by the utilities themselves, as a possible risk lies with the power company.

4.1.2 Testing Loads

The tower must be tested for the actual design load cases as defined by the Client. The sequence of the individual load cases should be selected with respect to the increasing forces in the tower members during the testing, if possible.

Load cases may be of the following types:

(1) Wind loads
Wind directions perpendicular and under 45 deg. to the line.
(2) Ice loads
If present, uniform ice as well as non-uniform ice with bending and torque conditions.
(3) Wind and ice loads
Combined wind and ice loads, if precribed.
(4) Special loads
Broken conductor, cascading loads and stringing condition.

The above-mentioned load cases correspond to IEC publication no. 826 and will generally cover the different types of loads specified by the clients.

The loads are normally given by the Client in a loading diagram for each load case.

Loads may be specified as working loads, design loads or ultimate loads. As testing loads are ultimate by definition, all loads must be transferred to the ultimate state. Working loads are therefore to be multiplied by the safety factor (most often between 1.5 and 2.0), while design loads are to be multiplied by the strength coefficient on the steel (typically between 1.1 and 1.25). The Client will specify the above-mentioned factors in the specification.

A destructive test may be carried out for worst load case after all other testing has taken place. The reserve strength capacity of the towers is most often within the range of 5 to 10%.

4.1.3 Testing Specifications

The IEC publication no. 652, 197?, will normally be applied as standard specification with some additional requirements.

The object of the IEC 652 is to codify the methods of testing towers and structures of overhead lines for voltages above 45 kV. These tests are made on the prototype prior to manufacture (prototype tests). Under certain conditions these tests may also be made as acceptance tests on a batch of towers.

The publication specifies test criteria, load application, sequence of loading test cases, check of tower mechanical strength, procedure in the event of premature collapse, check of quality of materials used for protype test, and finally, presentation of test results.

Towers could be specified to be galvanized to give the most reliable testing reflecting the conditions on site.

The calibration of all instruments used may be required to be tested by an independent authority.

Deflection readings in vertical, transversal and longitudinal directions will normally be recorded.

The loads of the final 100% step should possibly be maintained for a period of 5 minutes. After this step, sufficient time for full examination of the structure must also be allowed to check any permanent distortion or failure.

The testing station will normally be asked to carry out necessary strengthening of the test towers during the testing in the event of possible collapses of tower members or of apparently weak points.

Tested towers may be used for line construction at the discretion of the Client, preferably at positions not exposed to the maximum loads (i.e. at short wind span, small line angles). However, any tower member showing permanent deformations or elongation of bolt holes should be scrapped. Bolts including accessories should not be used for line construction.

Finally, towers could be required to be tested until destruction.

4.1.4 Testing Procedure

A complete sequence for testing of a high voltage tower should contain the following items:

(1) Testing of computer system, measuring equipment and winches. If a defect should be discovered during this test, there will be time for correction while the test tower is being erected and mounted.

(2) Drawing up of a sketch for each load case, showing the high voltage tower with coordinates, load sizes and codes (see section 5.7) for all the load points (including wind forces). Typing-in of data including control of all figures and tables.

(3) Erection of the high voltage tower.

(4) Visual inspection of the tower for control of the assembling and the fitting of the individual members.

(5) Mounting of steel cables for security. The steel cables are mounted by means of a manually activated, transportable winch.

(6) Mounting of dynamometers and reflectors for optical measuring instrument (see section 4.3.2) in the loading points (including wind forces) of the high voltage tower.

(7) Mounting of steel cables in the loading points (including wind forces) of the high voltage tower. The steel cables are mounted by means of a manually activated, transportable winch.

(8) The steel cables are streched to a suitable basis tension (with insignificant deflections of the high voltage tower). This is done by manual operation of the winches on site. After that, the winches are switched to remote control.

Now the high voltage tower is mounted and ready for test. The test for each load case proceeds as follows:

(9) On the unloaded high voltage tower the coordinates of the loading points are measured and recorded by the deflection measurement instrument (see section 4.3.2).

(10) The specified load for the given load step is applied to the tower.

(11) By giving a command the test operator initiates recording of pulling forces measurements, weather conditions, and time.

(12) The deflection measurement instrument is aimed at the loading point, and the coordinates are measured. The instrument calculates and stores the deflections compared with the last load step.

(13) By giving a command the test operator initiates the recording of reflections for each loading point in the computer. The measurements are transmitted as a telegram from the deflection measurement instrument to the computer system.

(14) The high voltage tower is photographed and carefully studied for visible deformations to the necessary extent, especially for load steps near the 100% final load.

(15) The operator proceeds with the test by going to item 10.

After completion of the test the operator activates the printing of a data report by giving a command.

The tower is dismantled or tested to destruction as agreed upon with the Client.

4.2 Mechanical and Physical Requirements

4.2.1 Typical High Voltage Towers and Testing Loads

The testing station must be able to test towers of the conventional self-supporting lattice type according to the specifications of EEA and with reasonable considerations to the designs applied abroad.

The primary basis for loads and sizes will be as follows:

(1) 220 kV Double Circuit Towers

Specifications and drawings have been submitted to the experts by Metalco.

The tower family consists of the suspension tower, three different angle tower types with a maximum line angle of 30, 60 and 90 deg. respectively, and in addition several special towers. The weights range from about 10 to 38 tons including extensions. Tower bases are nearly square and under 13.5 m, the overall heights are 53 m at a maximum, lower and upper crossarms approx. 27 m and 41 m, respectively, all figures include standard extensions up to 8 m. Maximum width of the crossarms is [illegible] m.

Maximum testing loads for the conductors will be 270 kN, [illegible] kN and 65 kN in the transversal, longitudinal and vertical directions, respectively. For the overhead earth wire the corresponding figures will be 80 kN, 45 kN and 20 kN. Testing wind loads on the tower body will be approx. 2.5 to 3 kN/m.

(2) 500 kV Single Circuit Towers

EEA's specifications for the 500 kV single circuit transmission line around Cairo will soon be available via Metalco. The next 500 kV line to be considered will be the interconnection to Jordan.

Towers are of the Y-type. Phases are triple bundles with 490/65 mm^2 ACSR conductors and 108 mm^2 steel wire strands as overhead earth wires. Spans are about 400 m at a maximum. Gust wind speed is 35 m/s. (Actual figures for pulling loads have not been provided during the preparation of the report. So, if necessary, the Consultant is to modify the mechanical capacity of the testing station in order to comply with the 500 kV towers).

(3) 33 to 400 kV Towers Produced by Metalco

Based on the drawings received from Metalco the overall measures appear to be as given below.

132 kV double circuit towers including single and double circuit towers for 33 kV: Sizes are within the above range of the 220 kV tower. However, the base of the 132 kV tension tower including a 15 m extension is about 15.2 m.

400 kV single circuit tower: Overall height including normal extensions is 41 m at a maximum, and the crossarms are about 33 to 37 m above ground. Widths of crossarms are in the range of 21.5 to 27 m. Tower bases will not exceed 12.5 m. The sizes will be within the range of the 500 kV towers mentioned above.

4.2.2 Geometrical Limits and Number of Winches

The overall limits to the tower geometry are recommended to be:

(1)	Tower bases	16 x 16 m
(2)	Crossarm widths	30 m
(3)	Tower heights	54 m

The number of loading points in each direction and the extent of the pulling forces are chosen as follows:

Item	**No.**	**Transversal**	**Longitudinal**	**Vertical**
Overhead earth wires	2	150 kN	150 kN	50 kN
Conductors	6	400 kN	400 kN	150 kN
Wind loads on tower	4	50 kN	50 kN	--

The total number of winches is to be 32.

The figures allow for a destructive test within 10% of the calculated capacity of the towers at a minimum.

The equivalent pulling forces for the wind load on the tower body will usually be limited to cover 10 m each.

Square and rectangular base towers will generally apply. The number of conductors on the same level will be limited to four at a maximum.

The mechanical capacity of the station will be sufficient for a wide range of towers about which the experts have information, including towers for moderate ice loads, (which could be the case for towers exported to e.g. Turkey).

Guyed towers will not be taken into account in the layout of the testing station.

Towers outside the range defined above are to be tested abroad, if possible. Minor exceedings of crossarm widths and tower heights will normally be acceptable to the clients as only small, if any, errors in the tests will be introduced. Extraordinary high towers (e.g. for river crossings) are to be tested without the lower part of the tower body.

4.2.3 Other Self-supporting Structures

The testing station will not be designed to cope with other kinds of self-supporting towers as testing of such towers is not required by the clients. Neither does Metalco plan to start a production af steel poles for overhead lines, which are therefore not to be taken into account in the design.

Testing of standard towers and poles for street lighting and free-standing antennas, etc. may, however, be subjected to testing from time to time in the future for reasons of research and optimization. Such tests can be carried out at the station within the mechanical limits as given above.

4.2.4 Site

The proposed site for the testing station is an approx. 95 x 175 m (i.e. 16,625 m^2) next to the Steelco factory at Helwan, 30 km south of Cairo, on the east bank of the Nile.

The existing access road appears to be sufficient, and the overall measures of the site will be suitable for the testing station.

Metalco will take care of all scrapping of materials and equipment discarded there. Also a small weigh-house under construction will be scrapped.

Photographs of the site are shown in Annex 2.1.

4.2.5 Control Building

Metalco expects the operating staff to include one manager, one testing engineer, one clerk, and one or two draftsmen, a total of five persons, maybe ten at a maximum.

The control building will be an approx. 100 m^2 one-storeyed house. The following floor areas appear to be suitable:

(1)	Computer and control room	15 m^2
(2)	Meeting room and offices	50 m^2
(3)	Entrance, toilets, etc.	10 m^2
(4)	Storage for mechanical equipment and spares. Dynamometer test bench	25 m^2

Items (2) to (4) are to be detailed by the Employer, and are not specified further in the report.

Auxiliary buildings for guards, possible storage and stocks of materials, etc. will be defined and detailed by the Employer.

4.3 Measuring Equipment, Computer System and Visual Documentation

This section contains the basic requirements for the measuring equipment and the computers.

Measurements are specified in the IEC 652.

4.3.1 Pulling Forces

The pulling force applied by the wires will be measured by dynamometers mounted between the loading points on the high voltage tower and the matching wires. One dynamometer will be needed for each main force; that is three conductors and one overhead ground wire for each circuit in the longitudinal, transversal and vertical directions. For the main forces, a total of 24 dynamometers.

Further, a dynamometer will be needed for each wind force in the longitudinal and transversal directions. All the wind forces will be applied at four discrete points. These forces will be measured by 8 dynamometers.

The output of the dynamometers will be an electrical signal (voltage or current) to be transmitted to the control room for monitoring and recording.

4.3.2 Deflections

Deflections of the load-points on the high voltage tower are measured by a total station (TS), an optical instrument mounted on a tripod which measures the distance in the X-Y-Z plane.

The total station will be placed in or near the control room.

A small reflector will be placed at each loading point of the high voltage tower, and the deflection is measured by aiming the total station towards the reflector, first in the unloaded position and afterwards in the loaded position.

The aiming of the total station is carried out manually.

One total station can measure the deflection of all the loading points.

The result of the total station measurements is the relative deflections (in mm) of each load point in the X-Y-Z direction together with the total deflection.

The deflections will be transmitted to the computer system in the control room through a RS 232 C interface.

4.3.3 Weather Conditions

Weather conditions (wind speed, wind direction, ambient air temperature) will be measured by a weather station placed in one of the steel structures. The measurements will be transmitted to the control room for recording.

4.3.4 Strain Gauges

The strain at selected points and directions of the members can be measured by strain gauges. These measurements, however, are not required by the IEC 652.

Measurements by strain gauges are therefore considered to be an option for this tower testing station, i.e. the station will not be equipped with strain-gauge measurements. However, it should be possible to extend the computer system for recording of such measurements.

4.3.5 Computer System

The purpose of the computer system is as follows:

(1) Controlling of the winches.

(2) Displaying of easily understandable tables and diagrams of the measurements during the test.

(3) Recording of measurements.

(4) Printing of data for test report.

The concept of the measurement and computer system is shown in Annex 4.3. The computer system consists of a PLC (Programmable Logic Controller) which picks up the measurements, and, if necessary, controls the winches. The PLC is connected to a PC (Personal Computer) equipped with a colour screen, a keyboard and a printer. The PC takes care of measurement display and handling of operator commands (Man - Machine - Interface). Further, the PC stores the measurements and prints the data for the test report.

The connection from the total station and the optional strain gauge equipment can be either through the PLC or the PC, depending on the manufacture of the computer system. This is shown by dotted lines in Annex 4.3.

4.3.6 Visual Documentation

According to the IEC 652, the test report must include photographs showing the whole structure and details of the defect, if any. The test station must therefore have a camera at its disposal.

Further, the entire test can be video recorded by one or more video cameras with matching video recorder.

Finally, the test station should have one or more binoculars at its disposal.

The purchase of equipment for visual documentation will be made by the Employer and will not be described further in this report, or in the detailed specifications to follow.

4.4 Miscellaneous Equipment and Facilities

4.4.1 Erection Crane

Metalco has at its disposal a Peiner Crane TN 85, which could be allocated to the testing station. With a minimum radius of 16 m the height of the hook will be approx. 75 m, and the lifting capacity 4.75 t. Crane specifications as per Annex 4.4. The figures appear to be suitable for erection of test towers.

Metalco will provide the rails and pertaining substructure for the crane. Further specifications will therefore not be made.

4.4.2 Communication Equipment

During the test the operator in the control room should be in radio contact with:

(1) The staff placed at the steel structure in the longitudinal direction.

(2) The staff placed at the steel structure in the transverse direction.

(3) The staff placed at the foundation for the winches at the test bed.

(4) The operator of the total station.

The test station should therefore have at its disposal a walkie-talkie system which is able to serve this purpose.

The testing station should be equipped with a speaker system for one-way communication from the operator in the control room to all the staff on the site.

Further, the control room is recommended to be equipped with two telephone lines:

(1) A telephone line for normal communication.

(2) A telephone line for remote maintenance of the computer system. The need for this line will depend on the manufacturer of the computer system.

The purchase and installation of the above-mentioned communication equipment are undertaken by the Employer, and are therefore not described further in the report, or in the detailed specifications to follow.

4.4.3 Workshops, Storage, Design Office

Furnishings and splices for connecting the tower legs to the footing devices at the test bed as well as plates and angles for possible reinforcement of the towers during the test will be provided by the testing station.

Stocks of spare bolts and accessories may also be necessary.

Finally, engineering and drafting services will be available for detailing and calculation of the above-mentioned steel accessories in connection with the execution of a tower test.

New space and buildings for workshops, storage, design office, etc. will not be necessary as existing facilities at Metalco are available.

4.4.4 Tensile Tests

A tensile test of the tower members is generally not required by the IEC 652. However, it may be necessary in some cases, or it may be required by the Client.

It is assumed that tensile tests can be carried out by an independent institute, e.g. the Technical University of Cairo. The testing station will therefore not be specified to be able to undertake this type of test.

5. SPECIFICATIONS

The Specifications are based on the best knowledge of the experts, the findings of the appraisal mission, and the requirements and factual conditions as discussed in sections 3 and 4 in this report.

Before any design is to commence the Employer will agree on the mechanical capacities and the instrumentation of the testing station as well as the contents of the Specifications in general as set out in the report.

During the detailed design the Consultant may conclude that the layout or mechanical capacity as well as instrumentation of the station should be adjusted to some extent. Any modifications for improvement of the testing station or limitations in capacity or instrumentation shall be agreed on between the Employer and the Consultant.

5.1 Description of the Testing Station

5.1.1 Layout

The main characteristics of the testing station can be briefly described as follows:

(1) A site of approx. 95 x 175 m situated at Helwan 30 km south of Cairo.

(2) A heavy, 54 m tall, steel structure in the transversal and longitudinal directions of the test tower, respectively.

The steel structures enable the pulling wires to be in the correct positions and levels for an actual test by mounting of movable pulleys in the structures.

Horizontal conductor pulls will be 400 kN at a maximum.

The foundation for the steel structure is of reinforced concrete and consists of a compression slab and a large anchor block for the back stay. 12 winches are anchored to the foundation at each steel structure.

(3) A test bed, i.e. a large foundation of reinforced concrete for anchoring of the test tower. The tower legs will be anchored by embedded bolts or rail devices by means of movable footings or auxiliary beams.

The working tension in the tower legs is limited to 3,000 kN, whereas the overturning moments are 100,000 kNm in each direction at a maximum.

Tower bases up to 16 x 16 m apply.

A foundation for 8 winches for the vertical pulling wires is placed near the test bed.

(4) A 100 m^2 control building with control room and facilities for staff and equipment.

(5) An erection crane including rails.

(6) Cable ducts and pavements interconnecting the steel structures, the test bed and the control building.

Outline drawings are enclosed in Annex 5.1.

5.1.2 Instrumentation

The measuring and reporting requirements of the testing station are described in section 4.3. To fulfil these requirements, the testing station should be equipped with the following measuring equipment:

(1) Dynamometers for measuring of pulling forces at each of the load points (including wind forces on the tower body).

(2) A total station for measuring of the deflections of the load points.

(3) A weather station for measuring of temperature, wind speed and direction.

(4) A computer system for monitoring and controlling of the test, and for printing of test report.

The proposed concept of computer and measuring equipment is shown in Annex 4.3.

5.2 Working Programme

5.2.1 Local Works

A summary of the local works is given below:

Item	Consultant	Employer
Foundations and civil works. Control building.	Basic design. Specification of control room.	Detailed design. Tender quotation and subcontracting of the works. Supervision.

Item	Consultant	Employer
Steel structures.	Detailed design. Supervision.	Production and erection.
Erection crane.	Not applicable (N/A)	Provision of a suitable crane.
Radio and tele-communication.	N/A	Provision of the necessary equipment.
Workshops. Storage. Design office.	N/A	Existing facilities at Metalco apply
Power installation.	N/A	Specifications. Installation. Supervision.
Tensile test facilities.	N/A	External facilities apply.

5.2.2 **Supplies**

A summary of the supplies from abroad and other services is given below:

Item	Consultant	Supplier
Mechanical Equipment.	Specifications. Supervision.	Production. Purchasing and erection by the Employer.
Measuring equipment and computers.	Specifications. Conditions of Contract. Supervision.	Production. Installation. Maintenance and service obligation.
Tower testing at commissioning.	Testing manual. Supervision.	N/A
Training within first year.	Programme. Supervision and reporting.	N/A

5.3 General Requirements

5.3.1 Obligations and Responsibilities

The works comprise the full and complete design, supply and installation of a tower testing station as detailed in the Specifications. All matters which may be necessary to ensure the efficiency, completion and operation of the station shall be included herein.

In the detailed specifications the interfaces between the different suppliers, and between the suppliers and the Employer shall be clearly defined by the Consultant.

Being the designer of the testing station the Consultant will be responsible for the correct function of the station so as to be sufficient to ensure reliability, safety in operation, and satisfactory performance in all respects.

Quality assurance systems shall be established and maintained during the execution of the works, including the design.

The Defects Liability Period for the completed testing station shall be specified to one year, whereas the responsibilities of the Consultant and contractors should be limited to five years.

5.3.2 Standards and Codes

All materials, equipment and workmanship shall generally comply with the requirements and latest revision of the standard and codes specified in the Specifications. Where not stated or being incomplete standards and codes of the following issuing authorities are preferable:

BSI British Standards Institution
DIN Deutsches Institut für Normung e.V.
IEC International Electrotechnical Commission
ISO International Organization for Standardization

A complete list of applied standards and codes should be included in any specification or tender.

All documents shall be prepared and all work carried out using SI units. The language shall be English.

All design, materials supplied, and work carried out shall comply with all applicable regulations to which the Employer is subject.

5.3.3 Service Conditions

For information the climatic conditions at the delta region of the Nile may be summarized as follows:

(1) **Temperatures**

Maximum air temperature in the shade	47 deg. C
Minimum air temperature	0 deg. C
Annual average	20 deg. C
Air temperature in the sun measured with black bulb thermometer	80 deg. C
Annual average maximum temperature in the sun	50 deg. C

(2) Maximum **rainfall** per 24 hours — 65 mm
Rainfalls occur mainly during winter and may be scarce.

(3) **Barometric pressure**

Maximum monthly average (winter)	772 mm Hg
Minimum monthly average (spring/summer)	749 mm Hg
Annual average	760 mm Hg

(4) **Relative humidity**

Maximum monthly average at 8 a.m.	83%
Minimum monthly average at 2 p.m.	44%
Annual average	75%

(5) **Gust wind speed** at small heights — 120 km/h

(6) **Salty deposits**
The atmosphere in the Delta region is frequently exposed to salty dusts due to the proximity of some salty lands, lakes and the Mediterranean. The salty deposits after condensation of humidity are not completely washed out by rainfalls. The density of salt deposits is 0.5 mg/cu.cm (aggregate deposit value).

The above-mentioned figures should be checked wherever they are of significant importance to the design of the testing station.

5.3.4 Materials

All materials specified shall be new and of the best quality, and of the class most suitable for working under the service conditions at the site.

Wherever possible all similar parts shall be specified to be interchangeable to enable easy substitution or replacement by spare parts in case of wear or other failure.

Where relevant, a list of spare parts for maintenance purposes during operation shall be required with the tenders.

All parts of materials and equipment shall generally be well packed and protected against loss or damage during transport by sea and over land and whilst in storage under local conditions.

5.3.5 Supervision and Testing

Testing of materials and equipment shall be specified to include all tests in accordance with the relevant standards, and in addition, any tests called for by the Consultant to ensure that all requirements have been fulfilled.

Supervision and testing during execution of the works shall be detailed in the technical specifications. A sufficient number of experienced supervisors shall be attached to the erection site.

Prior to commissioning a final inspection of the entire tower testing station shall be carried out by the Consultant.

5.3.6 Drawings and Manuals

All drawings are to be approved and shall be made in accordance with the instructions of the Consultant.

The Consultant shall prepare a schedule for number of documents, prints, manuals, micro films, etc. to be forwarded for approval and for final issue including as-built drawings.

A complete Operation and Maintenance Manual for the testing station shall be prepared by the suppliers and the Consultant in accordance with the list of contents specified by the Consultant.

5.3.7 Conditions of Construction and Erection

The Employer shall obtain all necessary permissions from the public authorities and other similar authorities to establish the tower testing station.

The Consultant shall define and describe the conditions of construction and erection in the specifications as agreed with the Employer. Transport, accommodation on the site, stores, supplies of water and electricity should be defined.

5.4 Foundations and Civil Works

5.4.1 Scope of Works

Execution of the civil works and the foundations will be undertaken by the Employer including the detailed design, subcontracting and supervision.

The work of the Employer will include the following:

(1) Preparation of the site for construction by scrapping of all discarded materials and equipment.

Furthermore, a survey and a field levelling of the site will take place so as to prepare a surveying plan of an appropriate scale for the Consultant's basic design.

(2) Execution of soil investigations in accordance with the instructions of the Consultant, and in such numbers as may be required for the assessment of the carrying capacity and the expected settlements of the soils.

(3) Specifications and detailed design of drains, water and electricity supply, communication lines, including trenches, as well as fences surrounding the site on three sides (the last side is towards the Nile approx. 50 m away).

(4) Specifications and detailed design of the control building in accordance with the instructions of the Consultant as regards the control room and installations in connection with the computers including necessary air conditioning units and special measures against dust.

(5) Specification of substructure for crane rails.

(6) Specifications and detailed design of pavements and cable ducts in accordance with the Consultant's layout drawing, and requirements for sectional area of the ducts.

The Consultant shall prepare the basic engineering for the foundations and the civil works in compliance with the above-mentioned requirements and the requirements below:

(1) Drawing of a layout of the testing station complete with all measures and location of all foundations, cable ducts, pavements, the control building together with recommendation for the location of the crane rails.

(2) Recommendations for levelling and compacting of the site.

(3) Information about the loads on the foundations and stating of the principles for calculation as well as recommendations and drawings in adequate numbers of the main geometry of the foundations in such a way as to provide the bases for the detailed design.

(4) Detailed design of all anchor bolts and devices.

(5) Specifications of standards, materials, workmanship including curing and finishing as well as tests and supervisory work during the execution.

5.4.2 Codes of Practice

The design and specifications shall be based on:

(1) Egyptian Code of Practice for Design and Construction of Concrete Structures, 1989.

(2) Egyptian Code of Practice for Soil Mechanics and Foundations, 1989.

The code will be in 10 chapters as follows:

1: Site Investigations
2: Laboratory Tests
3: Shallow Foundations
4: Deep Foundations
5: Problematic Soils
6: Foundations Exposed to Vibrations and Dynamic Loads
7: Retaining Walls
8: Stability of Slopes
9: Earthworks and Dewatering
10: Technical Expressions

The codes are under final issuing (January 1990) and will be in Arabic.

5.4.3 Soil Conditions

The general soil conditions along the Nile may be expected to be a 10 to 15 m upper layer of alluviale silts and clays underlayed by sand deposits. The water table will probably be 2.5 m below ground. Insels of soft clay are some times encountered due to the meandering of the Nile, but this is normally only farther on towards the north.

Shallow foundations should therefore be expected in general. Allowable soil pressures of 100 to 150 kN/m^2 will normally suffice, and also be adequate as regards limitation of settlements.

Proper soil investigations shall take place.

5.4.4 Design Criteria for Foundations

The foundations shall generally be made up of reinforced concrete. Foundation of the control building and construction of pavements and ducts will be carried out in accordance with local practice and the instructions of the Employer.

The test bed shall be able to withstand overall overturning moments of 100,000 kNm from the working loads in the pulling wires in the transversal and the longitudinal direction, respectively. The working tension in the tower legs is limited to 3,000 kN at a maximum. The test bed should therefore be calculated according to this criterion for tower bases between 16 and 2 m.

Interactions between moments in the transversal and the longitudinal directions shall be taken into account in such a way as to give a working tension of 3,000 kN at a maximum.

The safety factor on the working loads should not be below 1.5 when considering the stability of the foundations. Working loads may also be called characteristics loads.

A system of anchor bolts or embedded rails shall be designed to enable a safe and easy anchoring of movable footings or auxiliary beams, to which the tower legs are connected by means of splices. Square and rectangular tower bases apply, the length of the bases in the transversal direction to be the biggest, if different.

Foundations for winches and steel structures shall be designed according to the loads transferred thereto and as calculated during the detailed design and as given by the suppliers.

Anchor blocks for safety wires shall be specified including the embedded anchors of suitable type and robustness.

Anchor bolts and devices shall generally rely on the bearing stress and not the bondage to the concrete.

Pavements of adequate thickness and construction shall be specified around and between the compression foundation and the anchor block for the back stays, also allowing a proper foundation of the winches situated there.

5.5 Steel Structures

5.5.1 Scope of Works

The Employer will undertake all local works regarding the steel structures which include:

(1) Production and erection of the steel structures including painting, local transport and import of necessary supplies from abroad.

(2) Preparation of shop drawings, all detailing of gangways and ladders as well as erection drawings as deemed necessary for the execution of a proper job.

(3) Execution of material tests and non-destructive testing in accordance with the instructions of the Consultant.

The Consultant will prepare all the technical matters for the detailed design of the steel structures so as to provide the complete basis for the Employer's work as mentioned above, including the following items:

(1) Basis of statical calculations complete with full explanatory loading diagrams and application rules for pulling wires in the structures, wind loads and climbing loads, reactions on the foundations, etc.

(2) Elevations, plans, sections and details of the steel structures including anchor bolts and devices, assembly principles, etc.

(3) Specifications of materials, workmanship, coatinc and testing as well as instructions for erection.

(4) Description of the supervisory works during production and erection.

Further, the Consultant shall undertake:

(5) Approval of the Employer's drawings and supervision at the manufacturer's works, and during erection so as to ensure fulfilment of all requirements.

5.5.2 Code of Practice

The Egyptian Code of Practice for Steel Structures and Bridges, 1989, applies. The code is in English.

5.5.3 Steel Sections available in Egypt

The steel structures shall be made up of locally produced steel sections as mentioned below. Where sectional properties are inadequate sections are to be composed by welding at the works.

Item	DIN	Designation and Size
Angle	1028	L 40 x 40 x 4; 5
"	"	L 50 x 50 x 4; 5; 6
"	"	L 60 x 60 x 5; 6; 7
"	"	L 70 x 70 x 5; 6; 7; 8
"	"	L 75 x 75 x 8
"	"	L 80 x 80 x 6; 7; 8
"	"	L 90 x 90 x 7; 8; 9; 10
"	"	L 100 x 100 x 7; 8; 9; 10
"	"	L 120 x 120 x 10; 11; 12; 13
"	"	L 150 x 150 x 11; 12; 13; 14; 15; 16

Item	DIN	Designation and Size
Channel	1026	UNP 100
"	"	UNP 120
"	"	UNP 140
"	"	UNP 160
"	"	UNP 200
"	"	UNP 260
Beam	1025-1	INP 100
"	"	INP 120
"	"	INP 140
"	"	INP 160
"	"	INP 200
"	"	INP 260
"	1025-3	HEA 180
"	1025-5	IPE 400
Plate		PL 5; 6; 8; 10; 12; 14; 16; 18;
"		PL 20; 25; 30; 35; 40

Rounds of standard diameters between 6 and 100 mm also apply. Standard steel grade available is St 37-2 according to DIN 17.100. Angles and plates of thickness 5 to 20 mm should be available in grade St 52-3 as well.

Bolts and accessories are imported goods.

Ladders and gangways of expanded metal are of the Employer's own design.

5.5.4 Basic Design Criteria for Steel Structures

Load cases will be of the following types:

(1) Pulling loads and reduced wind loads
(2) Maximum wind loads
(3) Negative "pulling" loads and reduced wind loads
(4) Climbing and mounting loads.

The steel structures shall generally be dimensioned for positions of pulling wires which give the maximum load in the individual members.

The reduced dynamic wind pressure shall not be taken lower than 0.25 kN/m² which equals a gust wind speed of 20 m/s. The maximum wind speed allowed during testing should, however, be limited to approx. 10 to 15 m/s in order to obtain proper test measuring and results.

Maximum gust wind speed will be approx. 120 km/h. However, this value should be confirmed by statistics or by government regulations.

Negative "pulling" forces in the structures may result from a (sudden) breakage of the test tower, which will release the pulling wires and thereby introduce accelerations opposite the pulling direction.

Reasonable figures covering this loading case are to be calculated by the Consultant.

Climbing forces on the members during erection of the structures, maintenance and mounting of wires and pulleys shall be taken into account. Also loads from provisional pulley booms or beams facilitating the mounting shall be included.

Gangways including railings, and ladders in adequate numbers shall be provided to facilitate mounting and maintenance of wires and pulleys.

Easily understandable instructions and loading diagrams shall be prepared showing the allowable positions of pulleys, angle of wires, etc. during the testing of towers.

Maximum working or characteristic pulling loads in the wires are recommended to be as stated in section 4.2.2. All pulling loads should be considered to act simultaneously.

Four conductors at the same elevation apply at a maximum, and the vertical separation may be considered to be 6 m at a minimum. Conductor loads shall be effective between 12 and 48 m, whereas overhead ground wires are between 18 and 54 m accordingly. The equivalent pulling forces from wind loads on the tower body should be separated 6 m at a minimum. These loads may be applied between 6 and 30 m above ground. The above limitations in attachment points of the pulleys apply for the maximum pulling loads and may be exceeded for lower loads if not being decisive.

The overall capacity of the steel structures, however, should not exceed the figures corresponding to the capacity of the test bed, see section 5.4.4.

The accuracy of the pulling wire angle as measured at the attachment point in the tower shall be within 1%, i.e. the level and the position of the pulley shall be within 1.0 m to a 100 m wire length.

Proposal for steel structures is shown in Annex 5.1.

Transversal loads and the pulling wires will be in the centre line of the test tower corresponding to the centre of the structure leg and back stay in this direction. 12 pulling wires apply here. However, small modifications within the above-defined wire angle accuracy may occur due to geometrical requirements or constraints.

Pulling loads from conductors and overhead ground wires in the longitudinal direction will have a small angle deviation depending on the width of the crossarms and the position(s) of the tower peak(s). By definition the tower wind loads shall be in the centre line of the test tower. At the corresponding leg a total of eight pulling wires apply, whereas the other leg supports four pulling wires.

For calculation of pulling loads the above deviations shall be observed in preparation of the test load schedules. The steel structure shall of course be dimensioned for the sloping component of the pulling forces. The centre line of the steel structure is turned about 3.5 deg. on the vertical axis so as to minimize the above-mentioned effect. The maximum width of the test tower crossarm is limited to 30 m.

The overall safety factor should generally not be taken lower than 1.65.

Bolt types and sizes should be selected in respect to reducing the different diameters to two or three at the most.

Different steel grades should not be specified for equal steel sections. Additionally, equal angle sizes are to be selected with a difference in thickness of 2 mm at a minimum.

Pulleys shall be easily mounted and fixed in the steel structures. Facilities for hoisting wires in adequate numbers apply. Bracings crossing the leg and thereby disturbing the free wire positions shall be kept at a minimum. Wires to the winches at the foundation shall run between the leg and the back stay. The level of the pulleys shall be able to be read on a scale appropriately fixed to the leg of the steel structure.

A beam anchored to the test bed shall support eight pulleys for the vertical pulls.

The extent of non-destructive testing of weldings shall be specified. Testing by means of ultra-sound and x-ray is available at the factories as standard procedure.

Corrosion protection of steel structures shall be specified to be by painting. The Employer recommends application of a two-layer oil paint with a total dry coat thickness of 60 microns at a minimum as being adequate in the present service conditions. The Employer will take care of the repair necessary during the erection and the following maintenance in operation.

Bolts should be galvanized. Also anchor bolts and embedded devices should be galvanized to a depth of approx. 300 mm below the concrete surface.

5.6 Mechanical Equipment

As mentioned earlier the pulling forces will be applied at the loading points by steel wires.

The steel wires, sheave blocks, tackle blocks, winches and all necessary connecting fittings are called the mechanical equipment. This also includes steel wires for securing the tower during the test. The design of the mechanical equipment will depend on the design of the steel structures (see section 5.5)

The entire mechanical equipment shall be supplied by one supplier of all the mechanical equipment. The installation will be provided by the Employer under supervision of the supplier.

The Consultant shall prepare the technical material for tender quotation. This material shall contain maintenance, list of spare parts and detailed technical specifications. Mechanical equipment will be purchased by the Employer.

Design, individual parts, and fastening of mechanical equipment are to be specified in detail. The specifications shall take into account the open air conditions under which the mechanical equipment will be operated and stored.

Further, the procedure for mounting and demounting of steel wires to the high voltage tower shall be specified. If transportable winches are to be used in this procedure, the winches shall be specified in detail as well.

The specifications of the mechanical equipment should contain the following items (the list is not necessarily complete):

(1) **Design**
Location of sheave blocks, tackle blocks and winches. Number of line parts to be used. Fastening of the steel cables to the steel structure and the high voltage tower (through the dynamometers, see section 4.3)

(2) **Steel cables**
Number, types, diameters, lengths and maintenance.

(3) **Sheave blocks**
Number, types, loads, diameters, fastening and maintenance.

(4) **Tackle blocks**
Number, loads, number of sheaves, types, diameters, fastening and maintenance.

(5) **Winches**
Number, types, sizes, line pulls (with the maximum length of wire on the cable drum), wire diameters, maximum wire lengths on the cable drums, cable drums (sizes, grooved/not grooved, etc.), cable angles, cable speed, electrical motors, motor controls, power requirements, fastening and maintenance.

The winches shall be constructed to cope with the brief on/off operation necessary for adjusting the pulling forces.

The winches shall each be equipped with weather resistant control panel for local operation and for switching to remote control. In remote control the winches can be operated from the control room. The winches shall be equipped with terminals for connecting cables for remote control.

The terminals for tightening of steel wires shall be equipped with a relay, which shall be activated to allow operation. The relay is activated by a security circuit. The security as well as the cabling for remote control is further described in section 5.7. The local/remote control switch shall be equipped with terminals for remote indication of the position.

The winches can be powered by 3 x 380 Volt AC, 50 Hz with earth connection. The power supply is provided by the Employer who will install weather resistant plugs at the foundations of the steel structures in longitudinal and transversal directions (12 plugs each), and at the foundation of the high voltage tower (8 plugs). At each of the named places, the Employer will also install a 220 Volt AC 50 Hz weather resistant plug with earth connection.

(6) **Connection fittings**
Number, types, fastening and maintenance.

In Annex 5.6 a provisional draft for the design of mechanical equipment is shown.

To ensure a well defined direction of the pulling forces the coordinates of the steel wire on the steel structure should be fixed regardless of the direction of the steel wire.

As shown in the figure, the steel wire from the high voltage tower meets the steel structure in a toggle block. This block actually changes the coordinates of the steel wire according to the direction of the steel cable. It can be shown, however, that this change in coordinates is insignificant for the determination of the direction of the pulling forces.

5.7 Measuring Equipment

The measuring equipment and computer system (including all cabling, cross fields and security circuits) shall be supplied and installed by one contractor for measuring equipment and computer system. This also includes a complete control desk with instrumentation, push buttons, cabling, racks for PLC and PC, and cross fields. The control desk is described in section 5.8.5.

The Consultant shall work out the material for tender quotation, including conditions of contract, technical specifications, maintenance, list of spare parts and training. Further, the Consultant shall point out possible suppliers, for measuring equipment, computer systems and control desk.

The conditions of contract should preferably be based on the Conditions of Contract for Electrical and Mechanical Works including Erection on Site, issued by FIDIC in 1987.

In section 4.3 the parts of the measuring equipment are briefly described. In this section the measuring equipment will be described further. This description should be the basis of the detailed technical specifications. This specification shall take into account the open air conditions under which the equipment will operate.

5.7.1 Dynamometers

The dynamometers measure the pulling forces in the steel wires. The principle of dynamometers is based on either:

(1) The force being measured by the elongation of a spring, or

(2) The force being measured by a strain gauge bridge on a steel bar.

The principles to be chosen shall be decided in the detailed specifications.

The security against overload shall be specified.

According to IEC 652 the measured force shall be within ±2% of the specified force. However, the precision of the dynamometers should be within ±0.3% of maximum load.

The output of the dynamometers shall be a voltage signal (e.g. 0-5 Volt, 0-10 Volt) or a current signal (0-20 mA, 4-20 mA). The 4-20 mA current signal is preferable because of the active zero force signal (4 mA), which makes it possible to distinguish a zero-force signal (4 mA) from a broken current circuit (0 mA). The dynamometer shall be equipped with a plug for connecting the signal cable after mounting of the dynamometer. The dynamometer shall be powered through the signal cable, either by the measuring conductors or by separate conductors.

The cable from the dynamometer is led down the high voltage tower to a weather resistant cross field placed at the base of the high voltage tower. The cable is connected to the cross field by the same type of plugs used for the dynamometers. The type of cable with plugs should be specified by the supplier of the dynamometers.

The cables and the plugs in the cross field shall be clearly marked with a code referring to the pulling force measured. The code could e.g. be as follows:

S1 indicates the electrical system 1,
S2 indicates electrical system 2,
W indicates wind forces.

R, Y, B and G indicate the three phases (red, yellow, blue), and the ground wire.

H, MH, ML, L indicate high, medium-high, medium-low and low placed load points for wind forces on the tower body.

L, T and V indicate longitudinal, transversal and vertical directions.

The code on a cable (in both ends) and the matching cross field connection could be e.g.:

S1RL: System 1, phase R, longitudinal direction.
S2YT: System 2, phase Y, transversal direction.
WMHL: Wind force, medium-high load point, longitudinal direction.

The code signs should further be in different colours for easy visual check of the wire arrangement.

From the cross field to the control room, one or more multi cables are led in cable ducts.

The cross field and multi cable(s) shall be supplied and installed by the contractor for measuring equipment and computer system.

The cable duct from the cross field and the lead-in to the control room shall be provided by the Employer.

The testing station, as an option, should have at its disposal a test rig for control of the output from the dynamometers. The Consultant shall work out material for tender quotation, including detailed specifications, for such a test rig. The test rig shall be supplied by a separate supplier. The Consultant shall point out possible suppliers or manufacturers. Alternatively, the calibration of the dynamometers can be carried out at a laboratory in Cairo.

In Annex 5.7 is shown an example of design of a test rig. The tension is led to the dynamometer by means of hydraulic cylinders, and the applied force is measured by a calibrated dynamometer. From time to time, the calibrated dynamometer has to be controlled and adjusted, e.g. at the Technical University of Cairo.

5.7.2 Weather Station

Weather conditions are measured by a weather station for measuring temperature, wind direction and speed. The weather station shall be mounted on one of the steel structures.

The output from the weather station is analog signals (voltage or current). Depending on the manufacture, the output for the wind direction can be one or two signals. The wind direction is then to be calculated by the computer system on the basis of these two signals.

The output from the weather station is led by a multi cable down the steel structure, through a cable duct to the control room.

The type of cable shall be specified by the manufacturer of the weather station.

The cable duct from the steel structure and the lead-in to the control room shall be provided by the Employer.

5.7.3 Total Station

The deflections of the loading points are measured by a so called Total Station. A Total Station is an optical instrument normally used for surveying, and it is capable of measuring distances with high accuracy (within a few mm).

The Total Station is mounted on a tripod and is set up for each test, e.g. on a terrace in front of the control room. The actual placing of the Total Station is not important as long as it is not moved during the test. When not used, the Total Station is stored in the control building.

The Total Station is powered by a rechargeable battery.

The measuring is made by aiming the Total Station at small reflectors placed at the loading points of the high voltage tower.

The deflection is calculated on the basis of the distance to the loading points before and after the load is applied. The Total Station has a built-in calculator for working out this calculation and storing the result. For each loading point, the deflection is calculated and stored.

After measuring a set of deflections for a given load case, the results shall be transferred to the computer system. Therefore, the Total Station shall be connected to the computer system through an interface, e.g. RS232, depending on the manufacture of the Total Station. The data transfer shall be carried out upon receipt of a request for data from the computer system. The communication protocol shall be specified by the manufacturer of the Total Station.

The connection between the Total Station and the computer is a cable, which is led from the Total Station to a cross field placed on the control building. The cable with plugs in each end shall be specified by the manufacturer of the Total Station. The cross field shall be equipped with matching plugs. The cross field shall be weather resistant.

From the cross field, the signal cables are led to the computer system. The lead-in to the control room shall be provided by the Employer.

5.7.4 Winch Control and Security Circuit

The cabling for remote control and indication of position of local/ remote control switch of winches shall be supplied and installed by the contractor for measuring equipment and computer systems. The cables are mounted in the terminals in the control box of the winch and led to a weather resistant cross field placed at the foundations of the steel structures in the longitudinal and transversal directions and the winches for vertical load, respectively. The cables and cross fields shall be mounted with matching plugs marked as described under dynamometers.

From the cross fields to the control room, one or more multi cables are led in cable ducts.

The cross fields and multi cable(s) shall be supplied and installed by the contractor for measuring equipment and computer system.

The testing station shall be equipped with an emergency circuit, which interrupts the control circuit for tightening of the steel wires by means of weather resistant push buttons placed at the foundations of the high voltage tower, the steel structures in longitudinal and transversal directions, and in the control room. The emergency circuit is indicated in Annex 4.3. The entire emergency circuit, except the relays in the control boxes of the winches, shall be supplied and installed by the main contractor for measuring equipment and computer system.

The cable ducts from the cross fields and the lead-in to the control room shall be provided by the Employer.

5.7.5 Strain Gauges

As mentioned in section 4.3.4, the purchase and use of strain gauges shall be an option for this testing station, and shall therefore not be described in detail by the Consultant. However, it shall be possible to extend the computer system to registrate measurements from strain gauges, and therefore this equipment will be briefly described in this section. This can then be the basis for specification of the wanted computer extension.

The necessary number of strain gauges is estimated at approx. 20. There are two principles of transmitting data from the strain gauges to the computer system:

(1) Each strain gauge is equipped with an amplifier which transforms the strain gauge signal into a voltage or current signal suitable for the PLC. Each amplifier shall be connected to a compensation strain gauge, mounted on an unloaded steel structure.

(2) All the strain gauges are connected to a common amplifier which scans the strain gauges on request from the computer system, and transmits the measurements to the computer system via a parallel or serial data connection. The amplifier shall be connected to a compensation strain gauge, which can be common to all the strain gauges.

The selection of a strain gauge system will depend on the prices.

For the sake of an optional strain gauge system, it shall be possible to extend the computer system with 20 analog channels and a serial/ parallel communication slot.

5.8 Computer System

The computer system and control desk shall be supplied and installed by the contractor for measuring equipment and computer system as described in section 5.6.

In section 4.3 the computer system is briefly described. In this section the computer system will be described further. This description should be the basis for the detailed technical specifications. The computer system will be installed in the control room which will be provided with air conditioning by the Employer.

5.8.1 PLC Hardware

The PLC (Programmable Logic Controller) is a special computer for process monitoring and controlling. The PLC contains the terminals for mounting of cables for winch controlling, dynamometer measurements, weather station and Total Station (depending on the manufacture of the PLC).

A PLC is normally made up of several modules which make it possible to adapt and extend the PLC for various tasks. The modules of the PLC are normally mounted in a rack, which again is mounted in a cabinet together with power supply (for PLC, measuring equipment and winch controlling) and power stabilizer. It is, however, possible that the PLC can be mounted in the control desk to be described later in this chapter.

The terminals for connection to and from the process (both binary, analog and Total Station signals) shall be galvanicly separated from the PLC.

The power supply will be 220 Volt AC 50 Hz with earth connection, provided by the Employer. The PLC shall further be equipped with a power stabilizer supplied by the manufacturer. The type of plug used for power supply shall be specified by the manufacturer.

5.8.2 PC Hardware

The PLC is connected to a PC (Personal Computer) or other equipment for monitoring and transmitting commands (depending on the manufacture of the computer system). Depending on the manufacture the Total Station can be connected to the PC.

The PC hardware shall be specified by the manufacturer. It is normally a standard PC provided with harddisk with sufficient memory for all the software, perhaps also for back-up software for the PLC. The PC shall further be provided with a floppy disk-drive to be used for storing test results. Back-up software for PC and PLC can also be stored on floppy disks.

The PC shall be equipped with a speaker for indication of alarms by a sonic signal.

The PC shall be mounted in a suitable cabinet, which may be in the control desk, to be described later in this section.

The PC shall be equipped with a keyboard for key-in of data and transmission of commands. The keyboard is normally a standard type.

The PC shall be equipped with a colour screen with a sufficient picture resolution to satisfy the requirements of data presentation.

The PC shall be equipped with a printer (black/white or colour) mounted in a soundproof box. The printer shall be used for printing of test results to be used in the test report, and also for operator activated dump of the screen display to the printer during the test.

The PC can be installed in the same cabinet as the PLC. The PC can be powered by the same power stabilizer as the PLC.

Depending on the manufacture, the PC can be equipped with a modem for remote maintenance and fault finding via a telephone line.

5.8.3 PLC Software

The PLC shall be provided with general software for handling alarms. An alarm arises as an unreceipted alarm. The operator then transmits a receipt from the keyboard which transforms the alarm into a receipted alarm. When the cause of the alarm disappears, the alarm also disappears. The unreceipted and receipted alarms are indicated on the PC-screen by flashing and changing colour of symbols. It is possible that a cause for an alarm disappears before the operator transmits a receipt. This situation will also be indicated on the PC-screen.

The PLC will supervise the security circuit. If the circuit is broken, an alarm shall be activated.

The PLC will be provided with software for measuring the signals from the dynamometers. The software will include the possibility of supervision of the measurements with alarms for too high pulling forces. The alarm limits will be a percentage of the load for the given loadcase at the given load point. The alarm limits will be keyed-in through the PC.

The desirable loads measured by the dynamometers for a given load case, that is the forces in the directions of the steel wires, will be stored in the PLC. Before the test for a given load case these forces will be calculated on the basis of the wanted loads in the longitudinal, transversal and vertical directions. These loads are keyed-in by the operator. Whether the software for this calculation will be put into the PLC or the PC depends on the manufacture.

The PLC will be provided with software for measuring the signals from the weather station. The extent of this software will depend on the type of signals from the weather station.

Depending of the manufacture, the PLC will be provided with software for communication with the Total Station (depending on the manufacture, this software can be programmed in the PC).

The PLC will be provided with software for controlling the winches, that is automatic tightening of the steel cables to the given load case. For each winch there will be a manual/automatic software switch operated from the PC-keyboard.

When in manual position, the winch can be operated by commands from the keyboard (that is 'tighten' or 'loosen').

When in automatic position, the winch will participate in the automatic tightening of the steel wires. The winch can only be put into automatic position when it is in remote control. If a winch is in automatic and is switched to local control, the winch is shifted to manual by the software, and an alarm is activated.

The automatic software will be provided with a software switch for start and stop. The program can only be started if the security circuit is closed (see section 5.6). If the security circuit is broken while the program is working, the program is stopped. When the program is started, an alarm will be activated for all the winches which are not in automatic position. After the operator has receipted the alarms, the program starts to operate the winches automaticly after a specified algorithm. The algorithm will be specified in detail by the Consultant.

An algorithm could be as follows:

(1) The relative difference (RD) between the measured and the wanted pulling force is supervised continuously for all the dynamometers with matching winches in the automatic position.

(2) The dynamometer with the greatest numerical value of RD is pointed out, and the matching winch is operated according to the sign of RD. The operation of a winch will continue in a minimum space of time. The time can be a function of the numerical value of RD (little value - short space of time, great value - long space of time).

(3) The winches may be operated at two speeds by using alternate on/off signals. The speed is determined by the lengths of the on/off signals. The speed can then be high when the numerical value of RD is great, and the speed can be low when the numerical value of RD is little.

(4) If one of the measurements from the dynamometers reaches its alarm-limit, the program stops. The operator will then unload the critical winch manually after which the automatic program can be re-started.

(5) During the operation of a winch, the change of the corresponding pulling force, i.e. the time gradient of the dynamometer measurement, will be supervised. When the winch pulls, the time gradient will be greater than a certain value, when the winch loosens, the time gradient will be less than a certain (negative) value. The values can be a function of the measured force (low force - low gradient, high force - high gradient). If this condition is not fulfilled, the automatic program will stop, and an alarm will indicate which time gradient has caused the stop.

The PLC will further be provided with software for communication with the PC.

5.8.4 PC Software

The PC will be provided with all the necessary software to make it function and communicate with all its auxiliary units (colour screen, disk drive, etc.)

The PC will be provided with all the necessary software and screen displays for transmission of commands and key-in of test data.

The PC will be provided with software for display of measurements as digits, bars and curves. There will be possibilities for flashing and changing of colours for the measurements. The design of the screen displays, treatments of measurements and alarm handling will be specified in detail by the Consultant.

In Annex 5.8 is given an example of a possible display of the load point forces.

The PC will be provided with a report generator for printing reports with test data and test measurements. In the IEC test standard is given a list of data which will be included in the test report. The report generator will be specified in detail by the Consultant.

In Annex 5.8 is given an example of a possible layout for a test data report.

The PC will be provided with software for storing test data and measurements on a floppy disk. It will be possible to print a test data report on the basis of data stored on a floppy disk.

Depending on the manufacture, the PC will be provided with software for calculating the necessary steel wire pulls to obtain the required loads. This software could also be installed in the PLC (see section 5.8.3).

5.8.5 Control Desk

A control desk will be installed in the control room. The purpose of the control desk is to hold instrumentation and push buttons for supervision of dynamometer forces and manual control of winches in case of computer break-down (back-up control system). In Annex 4.3 is shown how this back-up control system can be connected in relation to the computer system.

Depending on the computer manufacture, the control desk can also hold the colour screen and the keyboard.

Depending on the computer manufacture, the control desk can be used for installation of the PLC and/or the PC. If this is not suitable, the supplier will install other suitable cabinets for the computer system in the control room.

In Annex 5.8 is shown a proposal for a control desk design.

5.9 Control Room

The control room will be detailed by the Consultant.

As mentioned in section 4.2.5, approx. 15 m^2 will be available. The actual shape will depend on the groundfloor plan which is to be worked out by the Employer. The control room should be provided with a window large enough to overview the whole high voltage tower from the operator's seat.

The control room will be fitted as follows:

(1) A writing desk in front of the window. The desk is used for the colour screen and keyboard (and the PC) together with the sketch of the high voltage tower and other papers. Also, one or two chairs are needed at this table. The walkie-talkie system and microphone for the speaker system (see section 4.4.2) should be placed within the reach of this seat.

(2) A control desk in front of the window. The control desk holds the instruments for operating the testing station in case of computer break-down (see section 5.7.5).

(3) An auxiliary table (with chairs).

(4) If the computer system is not mounted in the control desk, there will be a cabinet for this purpose (supplied by the computer manufacturer).

(5) A printer mounted in a soundproof box.

(6) One or more tables for video monitors and recorders.

(7) One or more lockers for:

- Documentation.
- Test reports, recorded floppy disks, photos and recorded video tapes.
- Spare parts and testing equipment for measuring equipment and computer system.
- Binoculars, camera and film.
- Printer paper, printer ribbon, empty floppy disks.
- Video cameras and empty video tapes.

5.10 Power Installations

The power and lighting installations are to be specified and installed by the Employer. The power installations will fulfil the need of lighting, winch operation (see section 5.6), computer operation, (see sections 5.7.1 and 5.7.2), and crane operation. The electrical plugs to be used will be specified by the manufacturers of the computer system and the winches, respectively.

The Employer will further install adequate lightning conductors for the steel structures, the control building, and the high voltage tower.

5.11 Testing Manual and Tower Test

5.11.1 Testing Manual

The Consultant will prepare a complete manual for a tower testing procedure based on the requirements in IEC 652, and additional testing to destruction as an option.

Furthermore, all preparatory engineering work such as arrangement drawings and calculation of wire pulls and load steps, etc. shall be specified. Also necessary security measures and control procedures before and during the test including checking of equipment, calibration, correctness of the cabling, etc. shall be described.

Finally, the contents and the layout of the test report shall be outlined.

5.11.2 Tower Test

In connection with the commissioning of the station the Consultant shall supervise and perform a tower test in all details following the above-mentioned testing manual.

A full test report shall be prepared.

The test is seen to be a worked example with all drawings prepared for necessary fittings and splices, arrangement of pulling wires, etc., and tables filled in with the actual figures for the loads and geometry as well as an examination of the control procedures, etc.

Necessary modifications of the testing manual and the test report shall take place after the tower test. The test report and the final testing manual will be the basis of all future tests.

The tower, including all necessary fittings and splices, shall be provided and erected by the Employer. All winches and equipment will be applied during the test, i.e. a double circuit tower is to be tested. The Employer also provides all labour and staff for the testing.

A destructive test will follow the standard testing procedure.

5.12 Training

5.12.1 Training Programme

Training in operation of the tower testing station is suggested to be undertaken by the Consultant within the first year of operation.

The Consultant will prepare a training programme for the operational staff of the station. The programme is suggested to include three complete tower tests evenly distributed over the first year. The tests will comply in all respects with the testing manual mentioned in section 5.11 above.

The tests will be carried out by the staff and supervised by the Consultant.

Visits and training at other testing stations may also be possible and are, if convenient, to be detailed by the Employer.

5.12.2 Training Reports

After every tower test a training report will be prepared by the Consultant. The report will describe the factual conditions for the test and recommendations for possible actions, which might be taken to improve the test procedures and the progress of the training.

A copy of each test report will be enclosed in the training report.

After the third test a final report should be made stating the recommendations for additional training within the following year(s).

5.12.3 Maintenance of Equipment and Computers

Training in maintenance of the tower testing station will be limited to maintenance of mechanical equipment, measuring equipment, and computer system.

Training in maintenance will be described and carried through by the respective suppliers, and the training shall be included in the tenders.

6. BUDGETS

The budgets are detailed in the sections below. The overall amounts are as follows:

(1)	Design and supervision by Consultant	260,000 US$
(2)	Local works undertaken by the Employer	1,870,000 £E
(3)	Equipment and computers from abroad	930,000 US$
(4)	Training by Consultant	40,000 US$

The budgets total approx. 1,950,000 US$.

On completion of the Constultant's work it is recommended to prepare detailed budgets for the entire works.

6.1 Design and Supervision

Preparation of the detailed design and the technical specifications are estimated to require six man months for a senior civil and structural engineer, and five man months for a senior mechanical instrumentation and computer engineer.

Supervision and commissioning including the tower test will require four man months, whereas three man months should be allowed for the project management.

Based on the above-mentioned number of man months and pertaining technical assistance from draftsmen, office expenses, prints and documentation the estimated engineering fees amount to approximately 230,000 US$. Allowances for travel and accommodation expenses are estimated at 30,000 US$.

6.2 Local Works

During the appraisal mission in Cairo the experts were informed by Metalco about unit prices for a number of typical works as given in the table below. The quantities are estimated based on the proposed layout of the testing station. All prices are in Egyptian pounds.

Item	Unit	P/U	Quantity	Total Price
Levelling and compacting	sq.m	25	16,000	400,000
Fence on three sides	m	180	360	65,000
Foundations	cu.m	450	1,450	652,500
Control building	sq.m	650	100	65,000
Structural steel work	ton	2,500	275	687,500
				£E 1,870,000

Allowances for erection crane with rail and substructure as well as the cost of the land are not included.

6.3 Equipment and Computers

The estimated prices for mechanical equipment, measuring equipment, and computer system are based on enquiries at Danish suppliers. In Annex 6.3 the prices are divided up into the different parts of the mechanical equipment, measuring equipment, and computer system.

Item	Total Price
Mechanical equipment	550,000
Measuring equipment and computers	380,000
	US$ 930,000

6.4 Training

Preparation of training programme, instruction, supervision, and reporting including allowances for travel and accommodation are estimated at 40,000 US$.

7. TIME SCHEDULE

The proposed time schedule is outlined in Annex 7.

The overall completion time for the testing station will be 21 months from the commencement date of the Consultant's work. The main periods are as follows:

(1)	Detailed design	6 months
(2)	Local works	11 months
(3)	Call for tender of supplies and contract negotiations	5 months
(4)	Transport and production of supplies abroad	6 months
(5)	Installation of supplies	3 months
(6)	Commissioning including one tower test	1 month

Local works (2), and call for tender (3) will start after approval of the design. Local works (2), and production abroad (4) shall be finished within 11 months hereafter.

Annex
UNDP Report

UNITED NATIONS DEVELOPMENT PROGRAMME

Project of the Government of

the Arab Republic of Egypt

Project Document

Number and title : Construction of Eledtrical tower testing station

Duration : 2 Years

Project site : Cairo

ACC/ UNDP Sector and

Sub-sector : 0350

Government Sector and

Sub-sector : Industry

Government implementing

agency : Metalco,

Ministry of industry

Executing ageney : Government.

UNDP and cost sharing financing	
UNDP	
IPF	500,000
other (specify)	-------
Govt. or third part	
cost sharing (specify)	-- —
UNDP Cost sharing	
Total	500,000

Co- Operating Agency : UNIDO.

Estimated starting date : March 1989.

Covernment inputs : (Local currency)

(in Kind) L.E. 2.500.000

(in cash) - ——————

Brief description : Design stand for Testing Towers through :

1- Design the station (Know how and blue prints)

2- Supervision on construction and erection

On behalf of :	Signature	Date	Name/Tihe
The Government:	— —	———	———————
Executing Agency :	————————	———	———————
UNDP	————————	———	———————

United Nations official exchange rate at date of last signature of project document : $ 1.00 = L.E 2.37

Table of Contents.

5. Immediate Objectivs

5.1 Output

Activities

E. Inputs

F. Risks

G. Prior obligations and prerequisites

H. Project Review reporting and evaluation

I. Legal context

J. Budgets.

K. Annexes

I. Workplan

II. Schedule of project reviews, Reporting Evaluation

III. Training Programme

IV. Job Descriptions

V . Letter of Agreement

VI. Financial and Accounting Arrangements

A Context

1- Description of sub sector :-

Metalco is a public sector comany affiliated to the min stry of industry and was established in 1968 and is responsible for local manufacture of steel structure, currently the main products are steel frames for factories, buildings, tanks, and equipments, as well as production of steel towers for transmission lines 33, 66,220, 500, K.V.A for the ministry of electricity?

The annual production is approximarely 30000 ton expected to reach 40000 ton by the year 2000.

Metalco's budget is L.E 35,000,000 annually.

2- Host country strategy :-

The strategy is to design, manufacture and test the steel towers for transmission lines, 33, 66, 220, 500 K.V.A locally in order to prevent sending the towers abroad for testing purposes and hence improve balance of payments.

3- Prior or ongoing assistance :-

Metalco has previously made agreement of license with PEINER - AG -W. Germany) for manufacturing tower cranes, since 1976.

Currenty, Metalco is seeking technical assistance in :-

1. The design and construct the tower testing station.

2. Supply of Apparatus for tension, application and measuring of loads deflection.

4- Institutional framework for subsector :-

Metalco has its board of directors which draws up the future plans of the company and is suppoorted by legal administrative and financial deportments, the ministy of planning allocates the necessary funds for future expansion of the company.

B Project Justification

1- Problem to be addressed : The present sitvation :-

The Ministry of elecricity and Energy (end user) is in charge of the generation and supply of electricity and energy in various forms to all of the country .

The present electrical gird extends along the Nile walley and there are plans to extend it east and west to other parts of the country as well as reinforce and modify the gird north and south of the country. The demand for electricity has i increased 13% annually. The ministy of electricity has plans to construct new transmission lines through a series of steel towers estimated at 30000 tons annually.

Metalco is the main supplier in Egypt to manufacture such steel towers, and has modified the current factories using CNC M/C's (computerized Numerical control machines) with at tal investment about 10 million Egyption pounds to be capable to manufacture and supply such steel towers according to the international specifications, as well as provided the design office with computer to improve and increase the cqpacity of the design office.

The international specification of steel towers obliges the designer and manufacture to undertake loading and destructive tests to insure that the design fulfill all the actual loads.

Such tests are carried out in a tower testing station (Not available at all the country) . In order to accept the steel towers according to international specifications, the ministry of electricity requests Melalco (a a supplies) to proceed with the said tests. Currently the testing operations are carried out through interna tional testing stations which are copable to under take the tests.

The tests when accepted are according to international standards.

2- <u>Expected end of project sitution</u> :-

1. A fully functioning tower testing station operated by Metalco.
2. Increased design copablites of Metalco engineers.
3. Improved specifications and timing in deliveries to ministry of electricity.

3- <u>Target beneficiaries</u> :-

A- Metalco will be capable to produce steel towers and will cover the shortage in the local production.

B- Ministry of electricity to realise its expansion programmes from local sources.

C- Ministry of economy in view of less imports of steel towers.

4- <u>Project strategy and institutional arrangement</u> :-

A- The Ministy of industry has allocated funds (approx. L.E 2 Million) for the establishment of the station, 10000 squar metres of land has been specified and ready for the civil construction.

B- In terms of cost benefit analysis, the test station has apey back period of three years following which the fees for testing will be spared in hard currency.

C- Metalco has made the necessary arrangements concerned with the technical supervision and backstopping as well as administrative mangement of the UNDP financed inputs.

5- <u>Reasons for assistance from UNDP</u> :-

UNDP assistance exposes Metalco to a variety of competitive suppliers of appropriate technology.

6- <u>Special considerations:-</u>

This is a positive contribution towards self reliance in the testing and commissioning of electrical towers.

7- <u>Co - ordination arrangements</u> :-

Co- ordination arrangements will be sought with other developing countries through TCDC . Most of the devloping countries have not testing facilities for electric transmission towers.

8- <u>Countrpart support capacity</u> :-

Metalco has highly qualified professional staff capable of providing the necessary technical inputs. The goverment will provide adequate salaries for the employees as well as physical facilitites, office space and other types of consumable supplies.

C. <u>Development Objective</u>

The project will strenghten the sapacity of Metalco steelco in testing tower stations which prevently carried out abroad with annual costs approx. $ 1.00 Million annually. Balance of payment will be improved as well as the design capability in the local manufacturers.

D. Immediate Objective

1- Immediate objective 1

Acquisition of know how in the construction of the testing station.

1.1 Out put 1

Complete know how and blue prints in the construction of the testing station.

Activities :-

1.1.1 Drafting TOR for technology transfer.

1.1.2 Shart listing of potential supp lieres of techno logy (April - May).

1.1.3 Evaluation of offers (September - October).

1.1.4 Negotiation and concluding agreement with selected subcontractor (November 1989°

2- Immediate Objective 2

Adaptation and transfer of technology.

1.2 Output 2

Transfer of technology under know how agreement.

Activities

1.2.1 Identification of methodologies of testing and recruitment of a consuttant for demestration (January 1990)

1.2.3 Adaptation of testing rechnosbgies (Feb-March)

3- Immediate Objective 3

Upgrading of national capabilities in the testing techniques of electrical transmission Towers.

3.1 Out put 1

Organization of training programmes.

Activities

3.1.1 Selection of trainees (June 1990)

3.1.2 Implementation of training programmes (July August 1990)

4- Immediate Objectiv 4

Afully operational testing station for electric power towers.

Out put 1

The station will have acapacity of testing towers 33, 66.220, 500 K.V.A in 1990

Activities

4.1.1 Civil work in the station according to subcontractors specifications.

4.1.2 Medhanical work for the station according to the sub-contractor specitications.

4.1.3 Installation of equipments according to blue prints.

4.1.4 Fully operatiodd station 1991.

5- Immediate Objective 5

Submission of technical reports.

5.1 Output 5

Reports

Activities

5.1.1 Inception report

5.1.2 Mid-- term progress Report.

5.1.3 Final Report.

E. Iputs

Covernment Inputs	(inkind)
Land	1,000,000
Foundations, Buildings	1,000,000
Steel structure stand	500,000
	2,500,000

UNDP- Inputs

_ Sub contract	US S	200,000
- Fellowships/ stady Tows		50,000
- Consultants		30,000
- Testing equipment	-	220,000
		500,000

F. Risks

Risks are not applicable.

G. Prior Obligations and Prerequisities

The Government will make availale the necessary funds for stablishing the site and constaction work , also appointment of the notional staff from Metalco will be finalized and ready for start up.

H. Project reviews reporting and evalution

The project will be subject to tripartite review (joint review by repre sentatives of the government , Executing Agency and UNDP)at least onceevery twelve months of the start of full implementation.

The national project co-ordinator and/or senior project officer of the united Nations cooperating agency shall prepare and submit to each trupartite review meeting a project peroject performance evaluation report (PPER). Additional PPERS may be requested, if necessary, diering the project.

Aproject terminal report will be prepared for consideration at the terminal tripartite review meeting it shall be prepared in draft sufficiently in advance.to allow review and technical clearance by the excuting agency at least four months prior to the terminal tripartite review.

The project shall be subject to evaluation nine months after the start of full implementation (three months prior to the scheduled termination) (threemonths following termination) the organization, terms of reference and parties to the project document, plus any associated united nations agency.

Facilities for monitoring the project

The government will provide UNDP and cooparting agency their officials and consultants with facilities for servicing and monitoring the operation of the project at all stages. This will include import of vehicles into the country by UNDP and (executing agancy) and their resident officers as authorized by the ministry of foreign affairs. These vehicles will be exempted from customs duties and taxes, and can be disposed of at the request of UNDP and (Executing agency) with the approval of the ministry of foreign affairs by either local sale or re- exportation. In case of local sale, these vehicles will be exempted from custons dutus and other taxes if the sale takes place five years or more from the date of entry into the country.

I. Legal Context

This project document shall be the instrument referred to as such in article 1 of the standard basic agreement between the Government of the arab republic of Egypt and the United nations development programme, signed by the parties on 19 January 1987 .

The country implementing agency shall, for the purpese of the standard basic agreement, refer to the Government co-operating agency described in that agreement .

The following types of revisions may be made to this project document with the signature of UNDP resident representative only, provided he or she is assured that the other signatories of the project document have no objections to the proposed changes :-

A) Revisions in or in addition of any of theannexes of the project document;

B) Revisions which do not involve significant changes in the immediate objectives, out puts or activities of a project, but are c used by the rearrangement of inputs already agreed to or by cost in creases due to inflation and .

C) Mandatory and revisions which rephase the delivery of agreed project inputs or increased expert or other costs due to inflation or take into account agency expenditure flexibility.

J. Budgets .

See attached budget sheets.

Work Plan

Work Activities	Party responsible for activity
- Expert to come to Egypt for 2 weeks to prepare document for tender	UNIDO
- Submission of tender documents to potential sub-contractor	Metalco
- Receiving the offers and evaluations	Metalco
- Specifications of equipments	Sulcatracter
- Tender for perdrazing equipments and evalution	Metalco
- Delivery of equipments	Subcontractor
- Excution of the station (building, steel structure stand , and installation of the equipments.	Metalco
- Training Metalco personmel	Sulcantractor
- Supervision	,,
- start and tests	,,

schedule of project reviews? Reporting and evaluation

Triparte reviewd	(Technical) evaluation
Months after signature of the lincense agreement	
12	12
24	20

Annex III

Traing Programme

ITEMS	Subject of training	profession	No	Duration
1	selection of tension position	Engineer	2	4 weeks
		Technician	2	,,
2	operating the test	Engineer	3	,,
		Technician	2	,,
3	Recording the results	Engineer	3	,,
		Technician		,,
4	Evaluation the results Final report	Engineer	2	,,

ANNEX IV

BRIEF TERMS OF REFERENCE

The transfer of technology for the construction of testing stations for to test steel towers for transmission lines will be carried out thourgh know how and blue prints from a company or expert office with wide experience in that field. The required know how gives Metalco the right to construct the station to perform the tests of towers, and strength the capability of the company to produce the towers the surplus production of towers will be exported after satisfying the needs of the Ministry of Electricity. Detailed terms of reference will be elaborated by Metalco for bidding purpose.

United Nations ind .strial Development
ORGANISATION project in the ARAB REPUBLIC of EGYPT

JOB DESCRIPTION

Post title : Expert in the design for construction of test station of towers for transimission lines 33· 66 , 220 , 500 K.V.

Duration 2 Months

Date required 2 nd quarter of 1989

Duty station

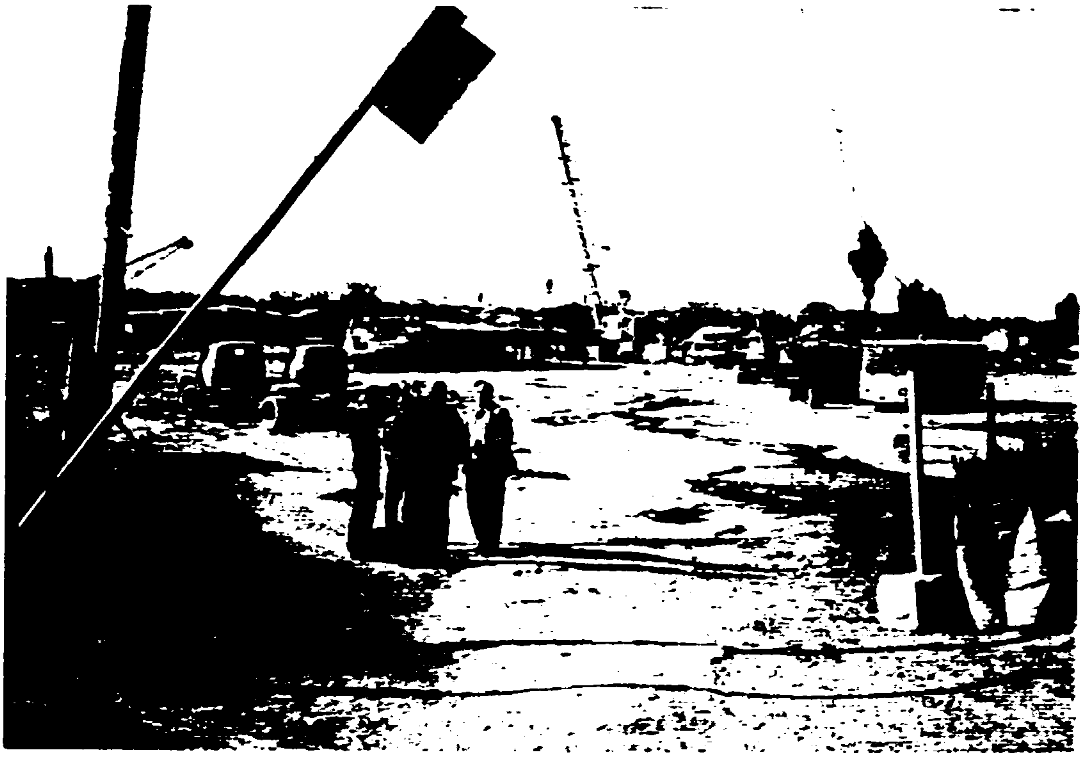
Puros of project To design and teview the specification for the building, structure and equipment necessary for the testing station.

Duties : The expert will proceed with the above mentioned and will be specifically copable to review the specification of building and Equipments.

Qualifications : Engineer with wide experience in the field.

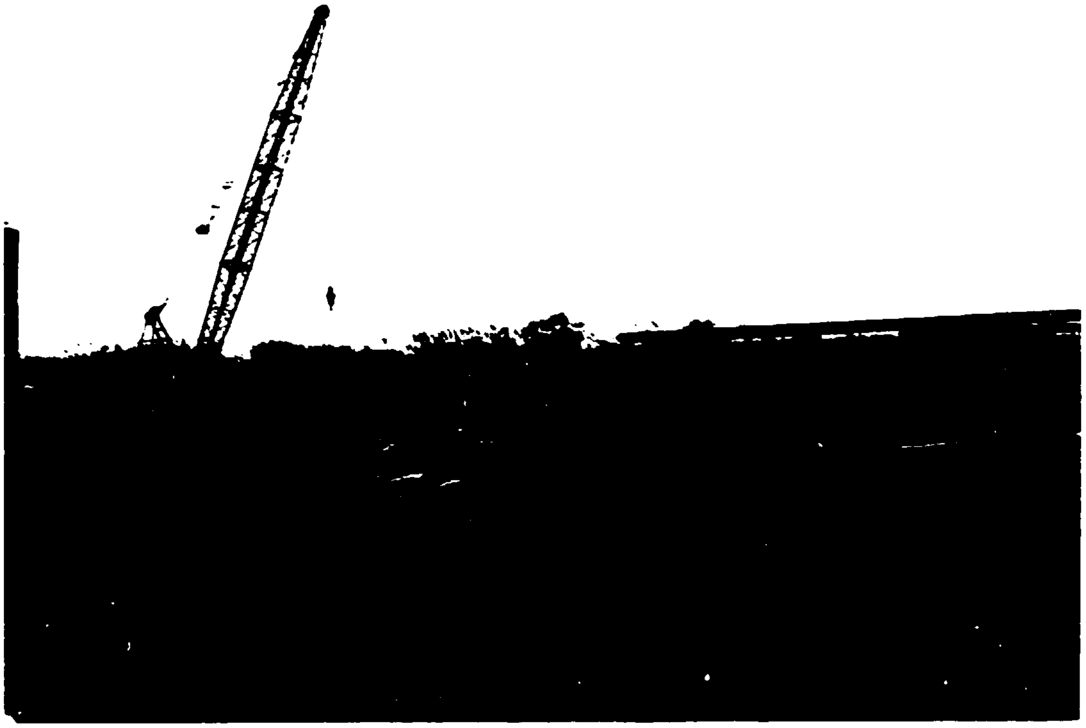
Langriage : English

Photographs of the Site and the Factories



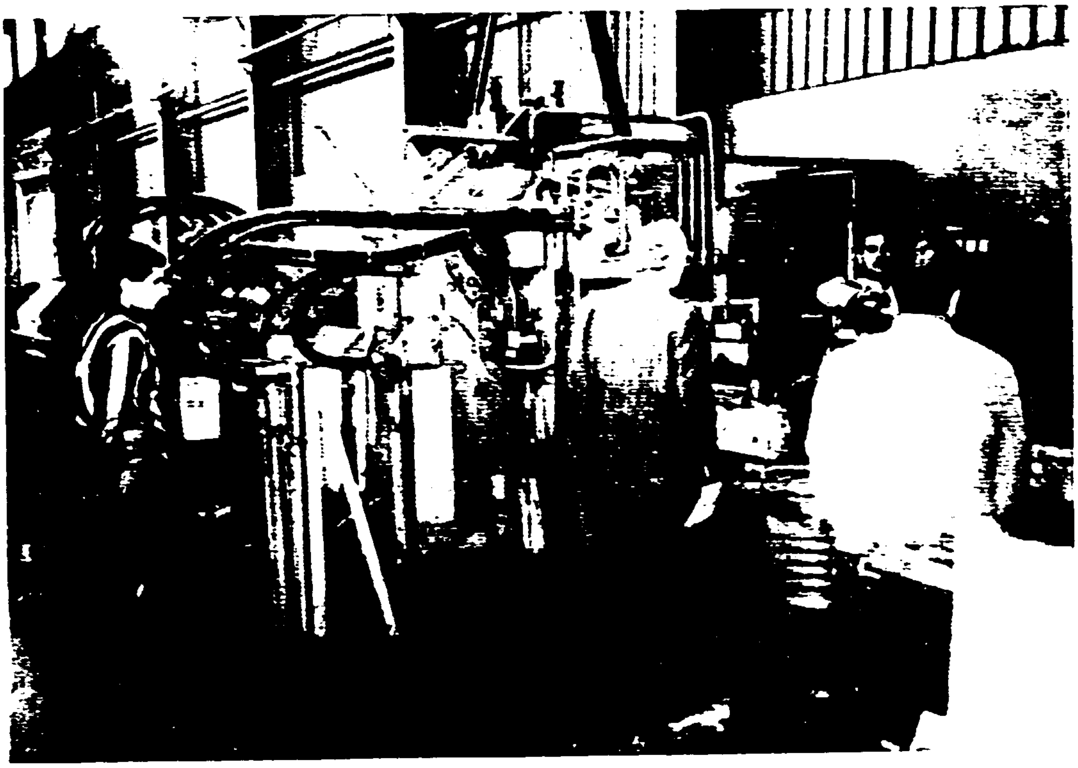
The site at Helwan seen from
the entrance towards the north.

The site seen from the north towards the south.
The Steelco factory in the background.

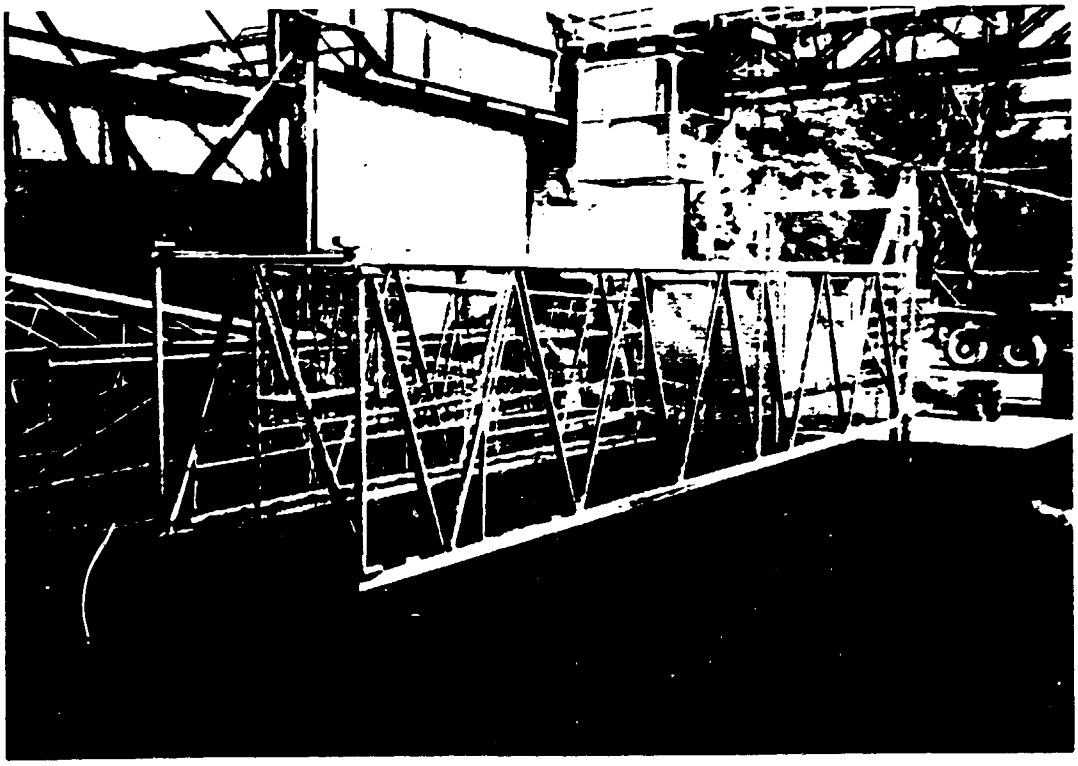


The site seen from the east towards the nile.

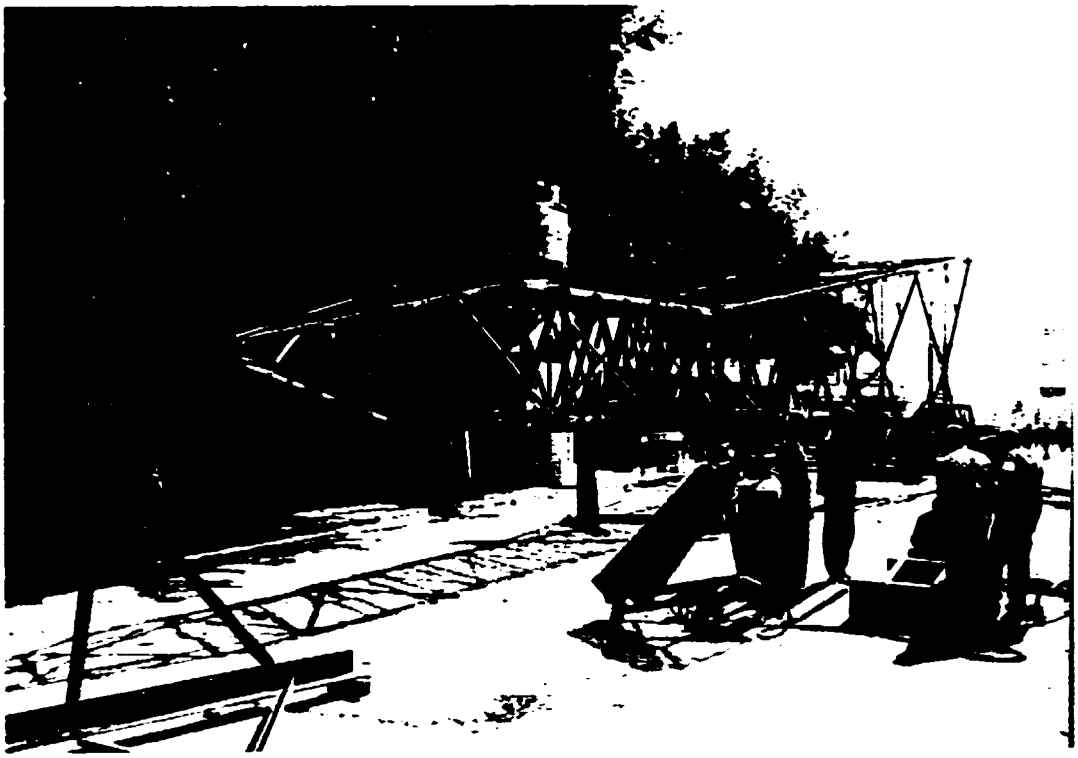
The site seen from the west towards the east.
A small weigh-house in the background.



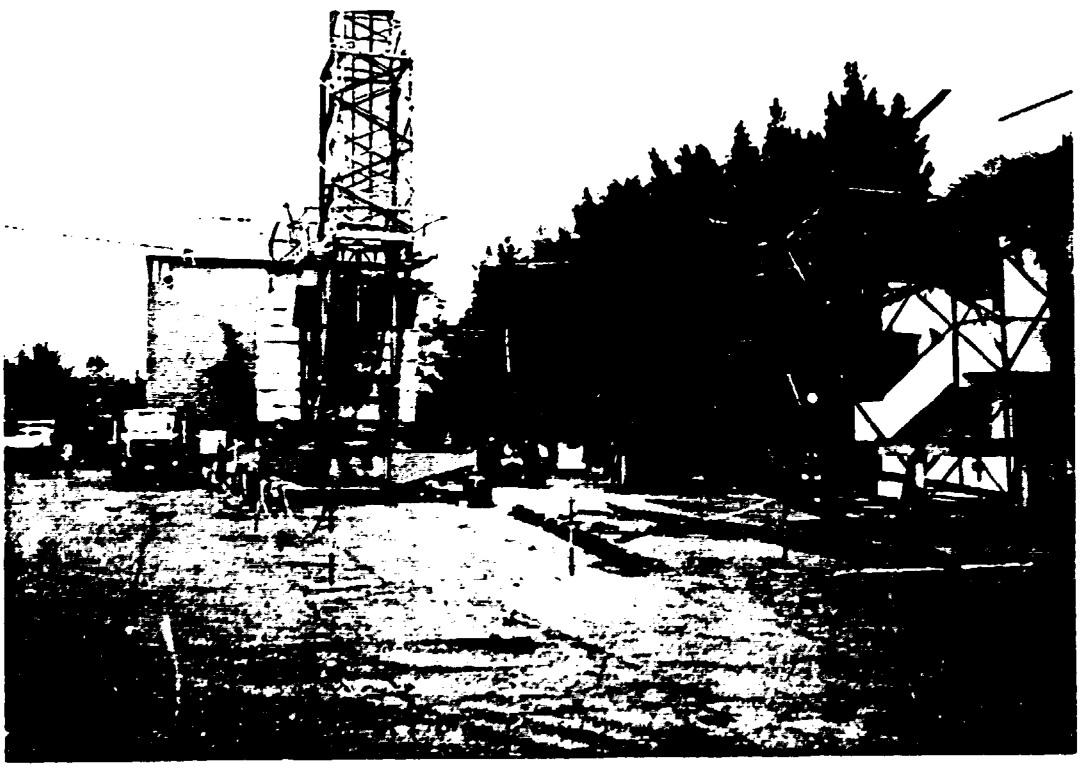
CNC line at the factory at Mezzalat.



Section of a tower crane.



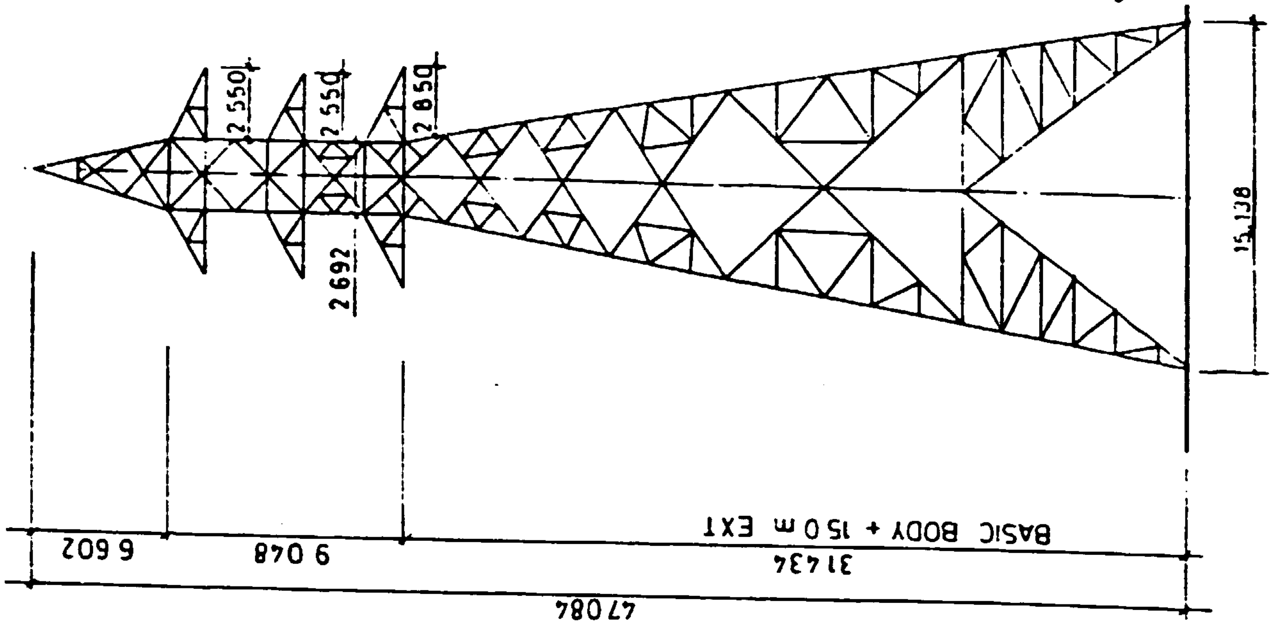
Assembly test of a high voltage tower.



Assembly test of a tower. The bottom
part of a Peiner crane is seen as well.

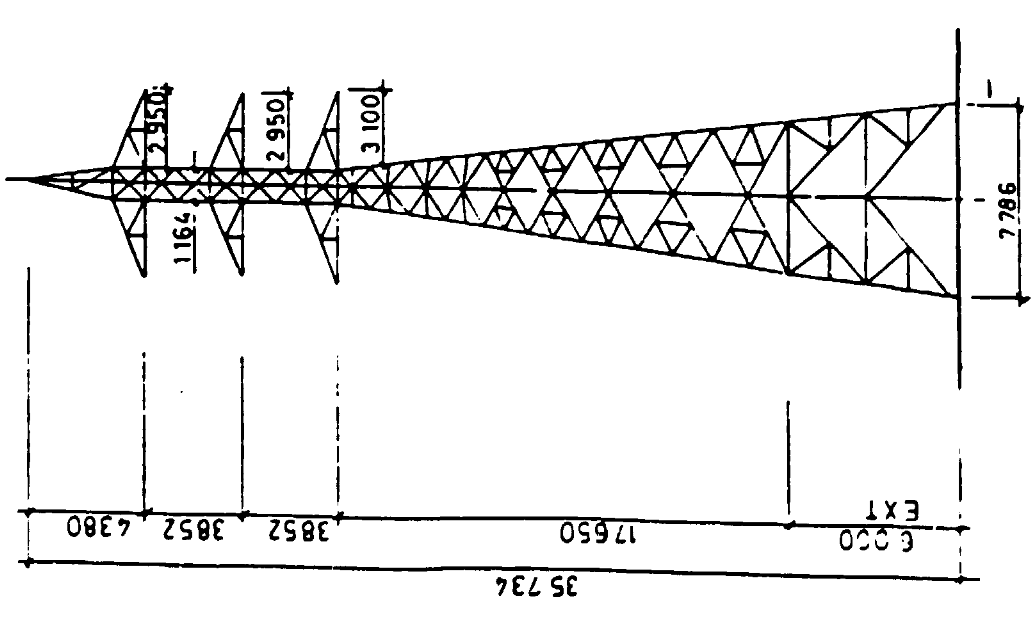
Annex

Typical Tower Layouts

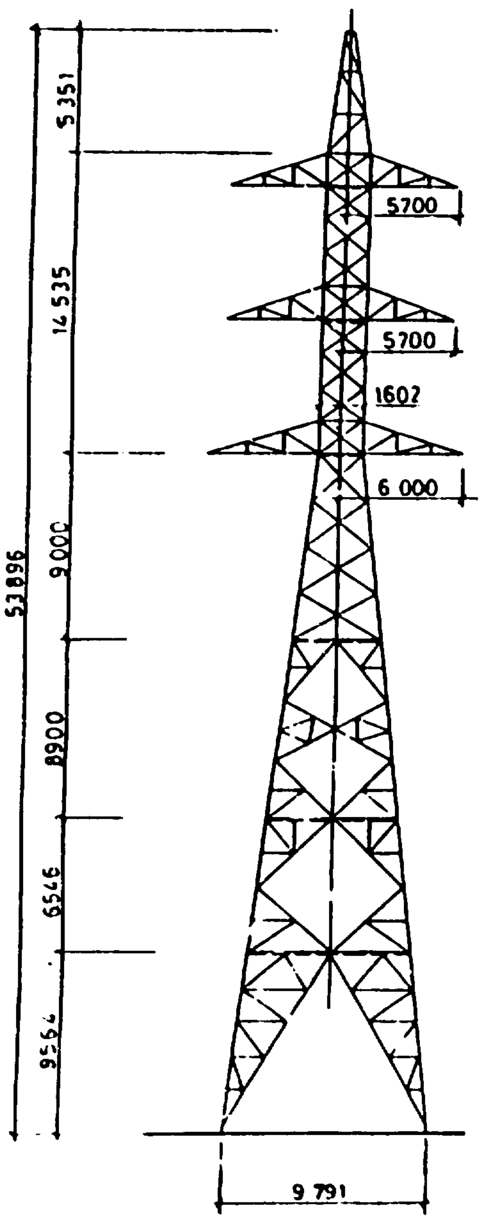


TENSION TOWER TYPE 2 T 2

132 kV

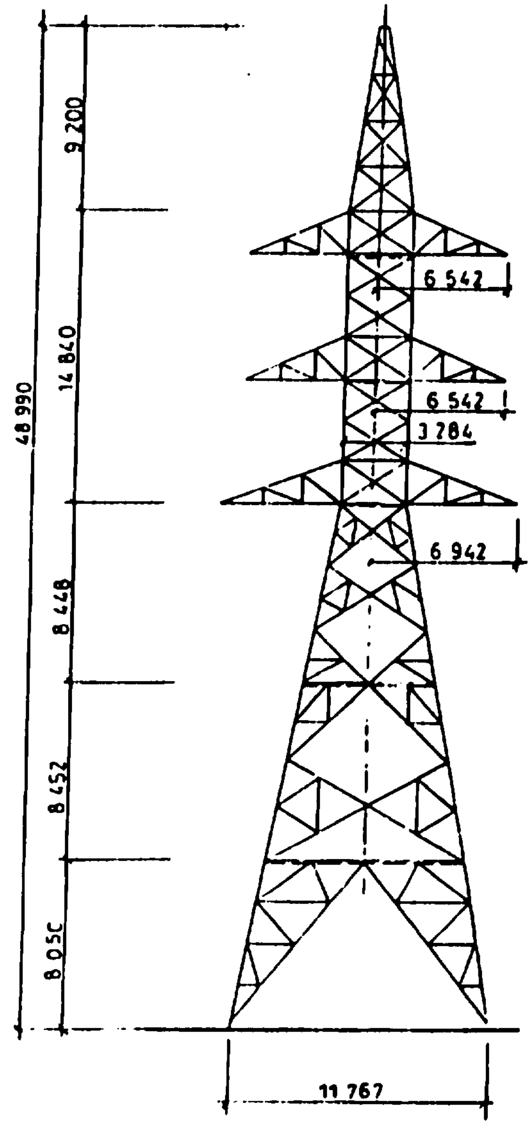


SUSPENSION TOWER TYPE 2S2

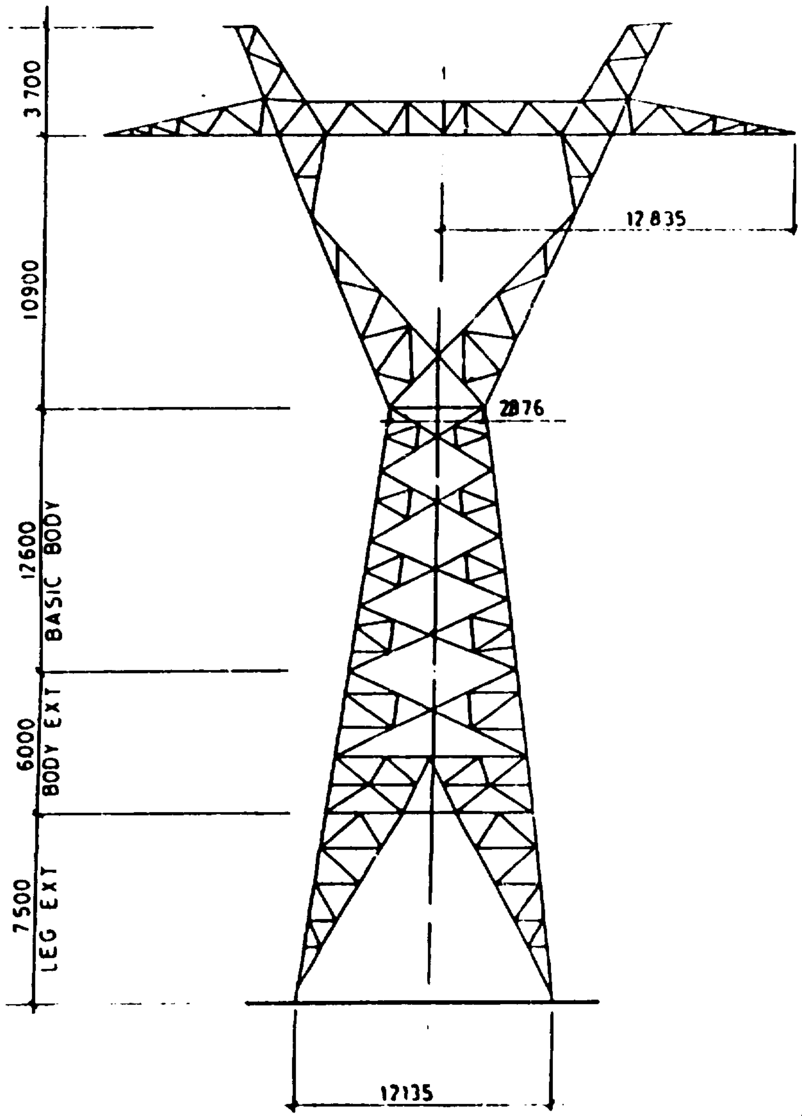


SUSPENSION TOWER TYPE KM DR-1

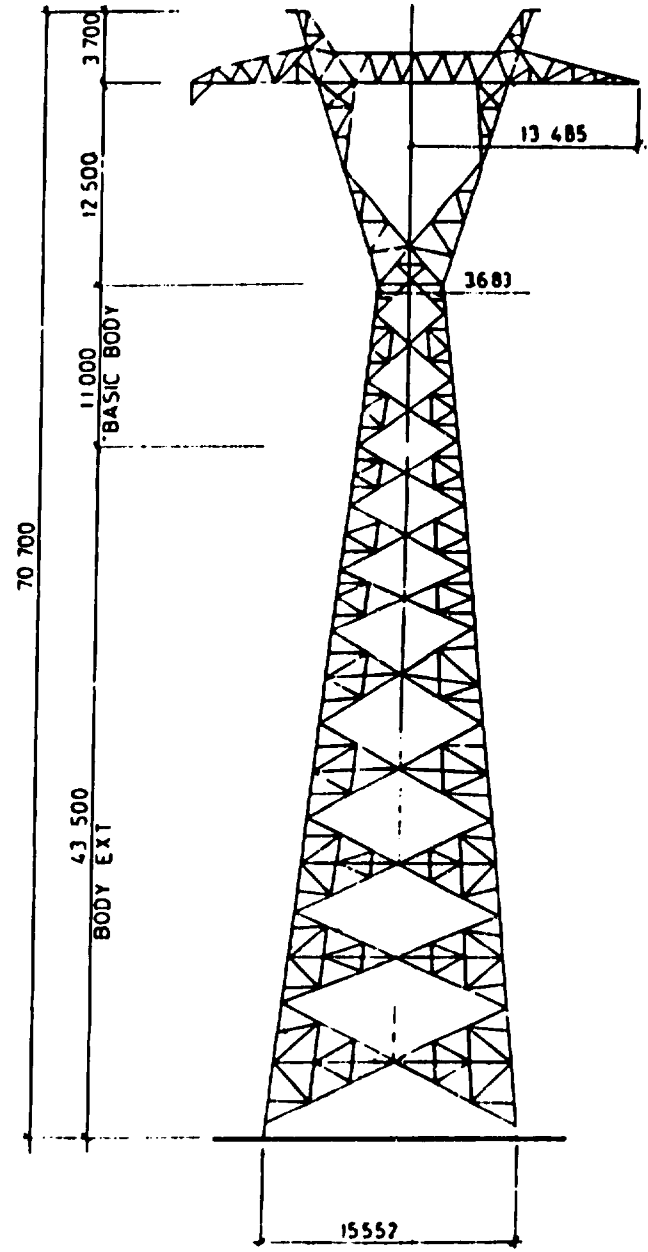
220 kV



TENSION TOWER TYPE KM 30-EB

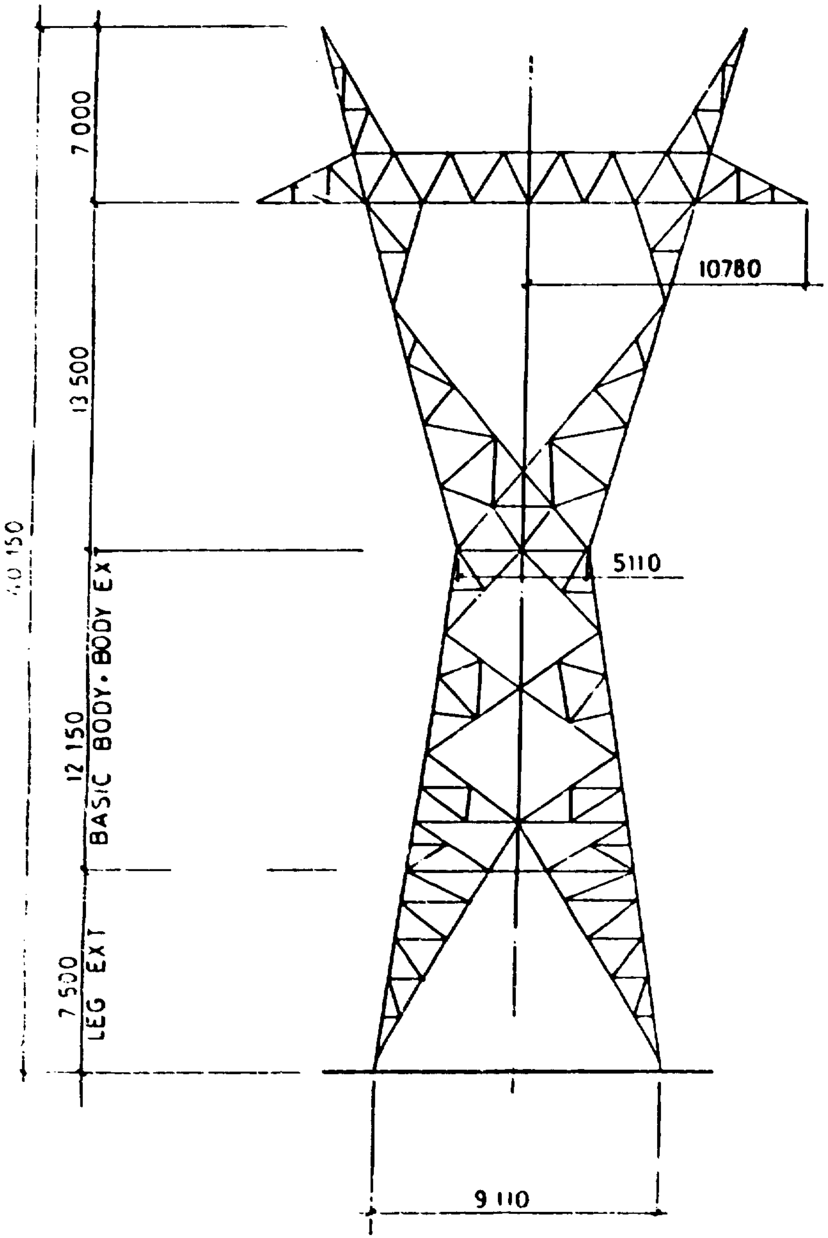


TANGENT TOWER TYPE X 4 A

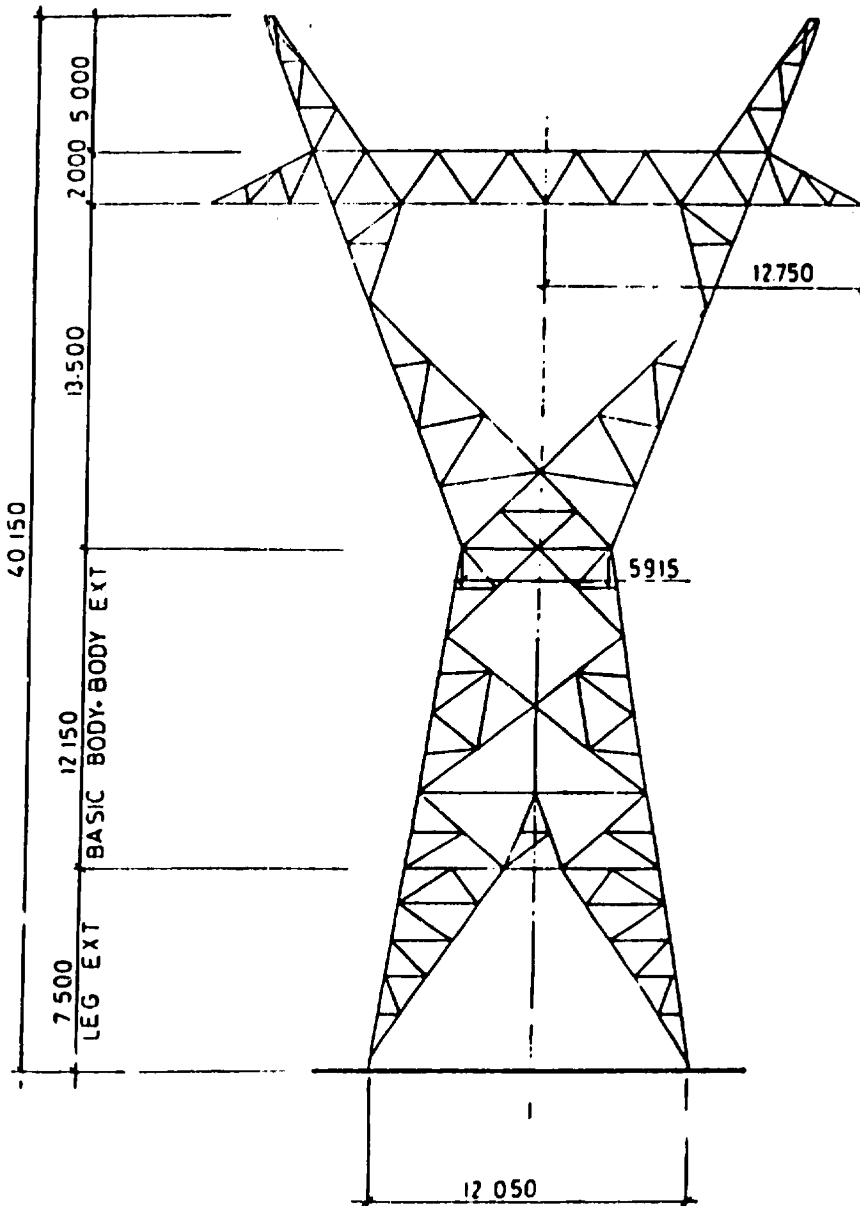


10 ANGLE - SUSPENSION TOWER TYPE X 4 B

400 kV



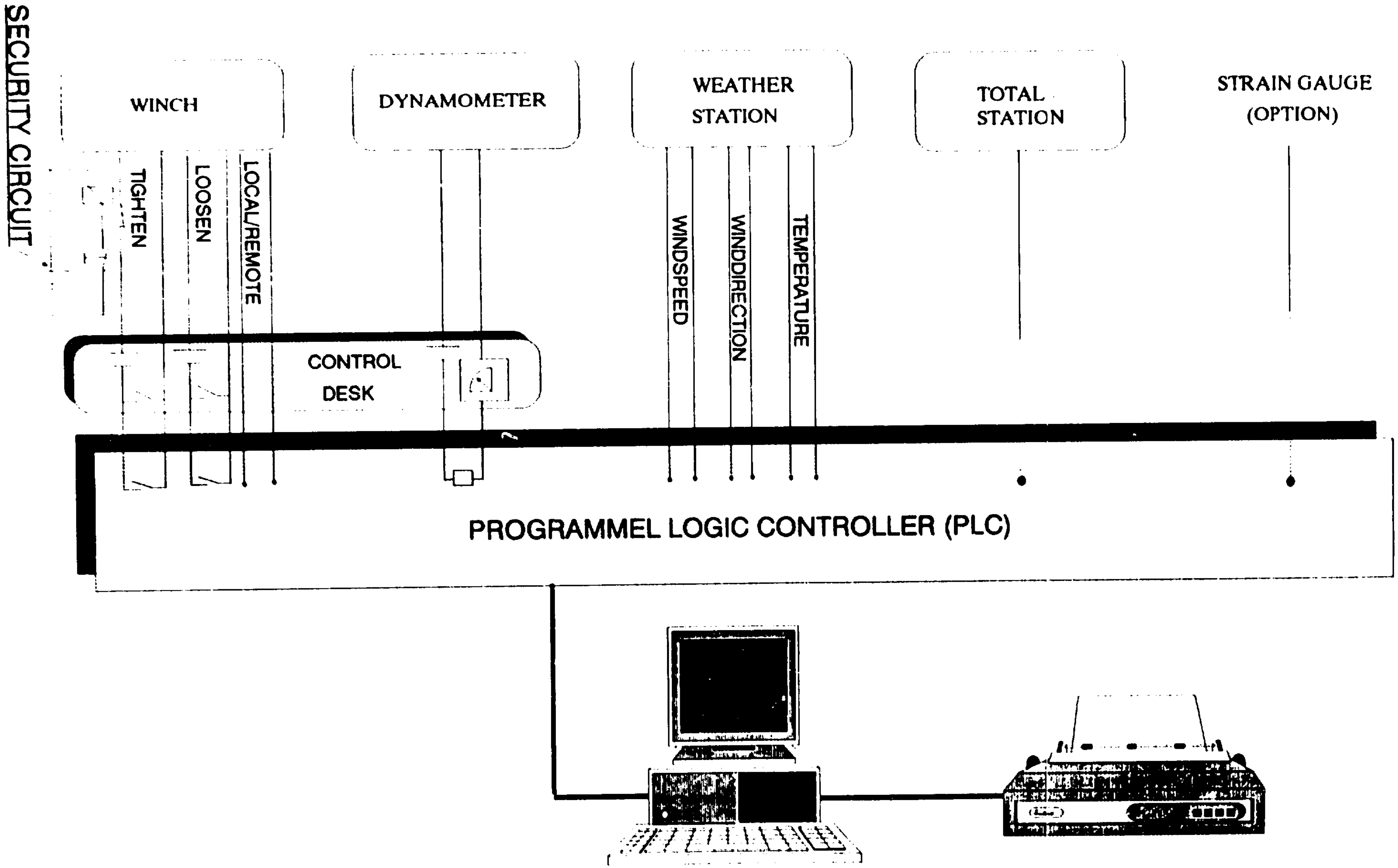
O - 45 ANGLE-SECTION TYPE X4C TOWER



O - 90 ANGLE-TERMINAL-SECTION TYPE X4D '

400 kV

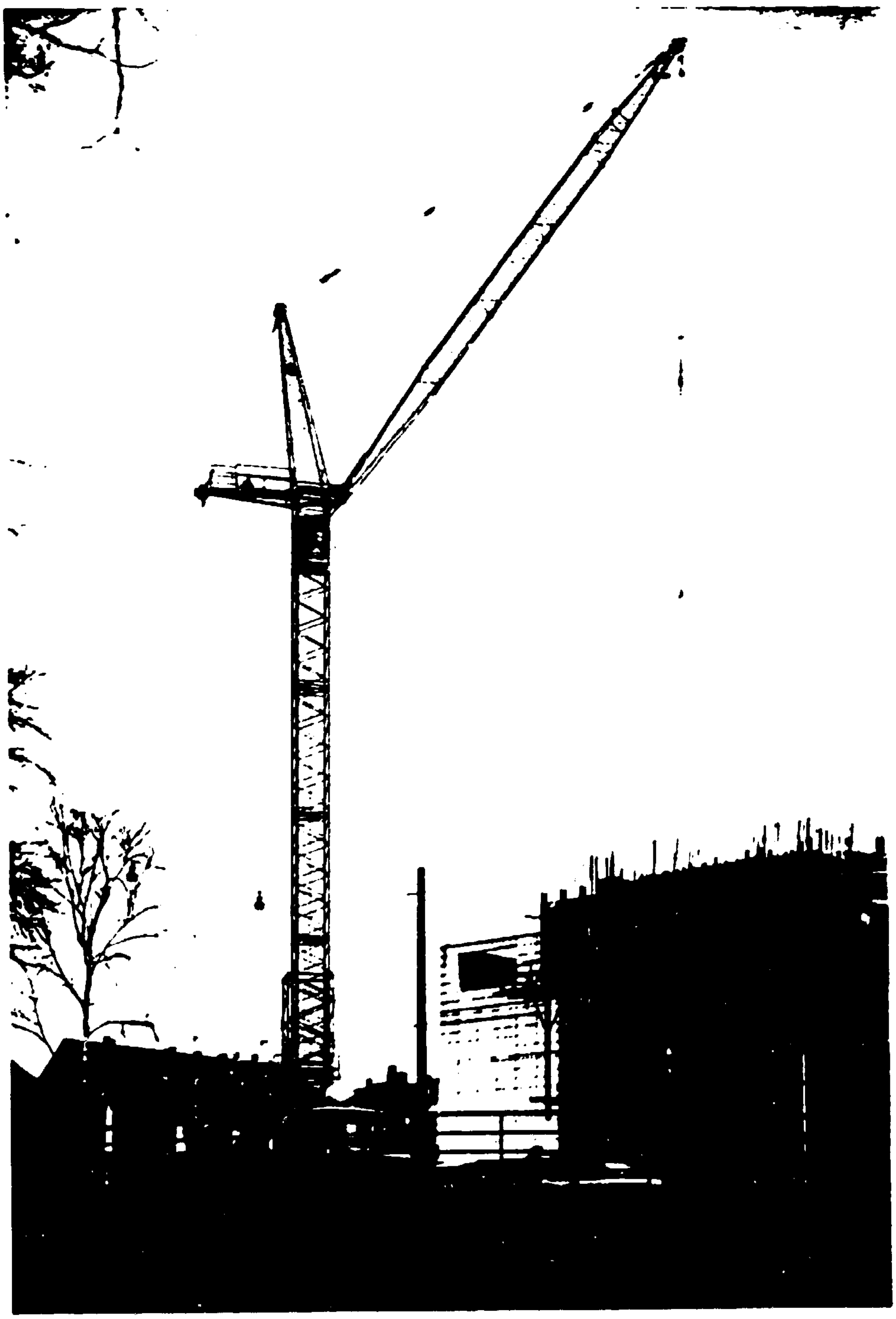
CONCEPT FOR COMPUTER AND MEASUREMENT EQUIPMENT



Specification Sheet

PEINER Crane TN 85

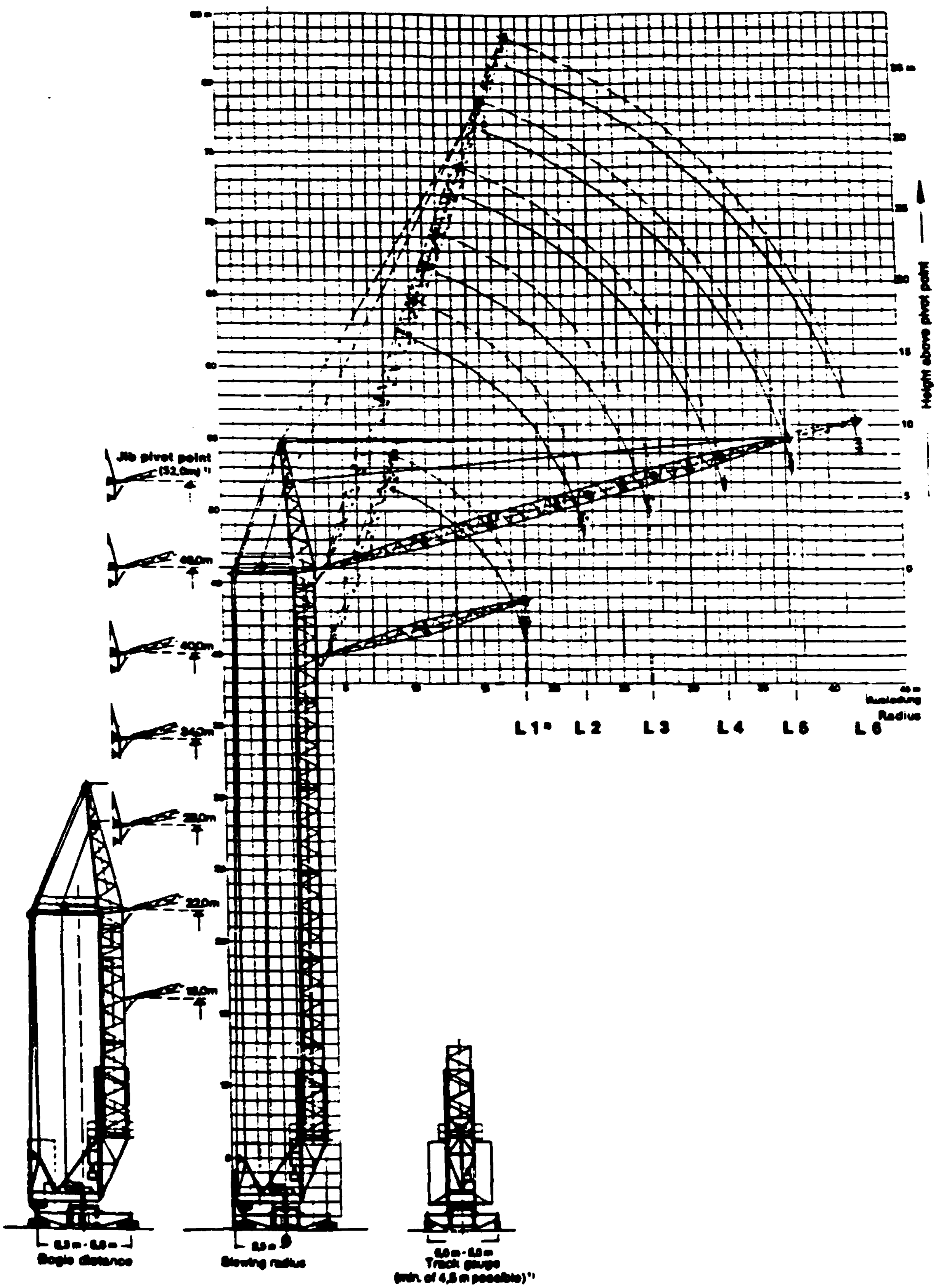
with luffing jib



Characteristics

Max. load moment	118 mt
Max. radius	42 m
Max. lifting capacity	12 t

TN 085.02 E



S – 5,0 to 5,6 m
track gauge of 4,5 m possible - see crane manual

1) Dimensions in brackets for possible special designs - see crane manual for operating conditions
2) Jib pivot point max. 40,0 m

Lifting capacities

Jib	L 1		L 2		L 3		L 4		L 5		L 6		
Max. radius in m	17,85		22,40		27,20		32,70		37,50		42,30		
Hoist rope	three part line		two part line		two part line		one part line		one part line		one part line		
Lifting capacity in t according to DIN 1)	120/I	15018 or 120/II	120/I	15018 or 120/II	120/I	15018 or 120/II	120/I	15018 or 120/II	120/I	15018 or 120/II	120/I	15018 or 120/II	Radius in m
	14,00	12,00											8,70
	12,95	11,10											10,00
	12,60	10,80	11,10	9,50									10,45
	12,25	10,50	10,79	9,25									11,00
	10,55	9,05	10,20	8,75	8,75	7,50							12,20
	10,67	9,15	9,91	8,50	8,51	7,30							13,00
	9,74	8,35	9,33	8,00	8,16	7,00	6,55	5,60					14,20
	9,15	7,85	8,92	7,65	7,87	6,75	6,35	5,45					15,00
	8,40	7,20	8,51	7,30	7,58	6,50	6,28	5,30	5,50	4,75			15,90
	7,64	6,55	8,06	6,90	7,23	6,20	6,00	5,15	5,36	4,60			17,00
	7,17	6,15	7,75	6,65	7,00	6,00	5,83	5,00	5,25	4,50	4,00	3,50	17,60
	7,00	6,00	7,64	6,55	6,94	5,95	5,83	5,00	5,25	4,50	4,02	3,45	17,85
			7,11	6,10	6,59	5,65	5,60	4,80	5,07	4,35	3,90	3,35	19,00
			6,65	5,70	6,24	5,35	5,36	4,60	4,90	4,20	3,85	3,30	20,00
			6,18	5,30	5,95	5,10	5,19	4,45	4,72	4,05	3,73	3,20	21,00
			5,55	4,75	5,48	4,70	4,90	4,20	4,55	3,90	3,61	3,10	22,40
					5,30	4,55	4,78	4,10	4,43	3,80	3,56	3,05	23,00
					4,95	4,25	4,60	3,95	4,25	3,65	3,44	2,95	24,00
					4,66	4,00	4,43	3,80	4,14	3,55	3,32	2,85	25,00
					4,31	3,70	4,20	3,60	3,96	3,40	3,26	2,80	26,00
					3,90	3,35	3,96	3,40	3,79	3,25	3,16	2,70	27,20
							3,85	3,30	3,67	3,15	3,03	2,60	28,00
							3,61	3,10	3,50	3,00	2,97	2,55	29,00
							3,44	2,95	3,32	2,85	2,85	2,45	30,00
							3,20	2,75	3,20	2,75	2,74	2,35	31,00
							3,03	2,60	3,03	2,60	2,62	2,25	32,00
							2,90	2,50	2,91	2,50	2,56	2,20	32,70
									2,74	2,35	2,45	2,10	34,00
									2,62	2,25	2,33	2,00	35,00
									2,45	2,10	2,27	1,95	36,00
									2,27	1,95	2,16	1,85	37,00
									2,20	1,90	2,10	1,80	37,50
											2,04	1,75	38,00
											1,98	1,70	39,00
											1,86	1,60	40,00
											1,75	1,50	41,00
											1,65	1,40	42,30

1) This crane has been designed according to DIN 15018 – Hoist Group H 1 / Load Group B 3 – and incorporates the newest technical features. As long as DIN 120 remains in force the crane can also be classified in Crane Group I or II according to DIN 120.

Technical Data

Working Speeds and Motor Powers

Hoist		H 1	H 2	H 3	H 4	H 5	H 6
Power[1] in kW (PS)		23.5 (32)	30 (40)	23.5 (32)	23.5 (32)	30 (40)	28 (38)
Hoisting in m/min (one part line)	4th gear	–	–	–	–	100 to 1.4 t 160 to 0.4 t	100 to 1.4 t
	3rd gear	63 to 2.0 t	63 to 2.5 t 100 to 0.8 t	63 to 2.0 t	63 to 2.0 t 100 to 0.4 t lowering	63 to 2.24 t 100 to 0.6 t	63 to 2.24 t
	2nd gear	50 to 2.5 t	50 to 3.2 t 80 to 0.8 t	50 to 2.5 t	50 to 2.5 t 80 0.4 t lowering	40 to 3.8 t 63 to 1.0 t	40 to 3.8 t
	1st gear	22.5 to 5.6 t	22.5 to 5.6 t 35.5 to 0.8 t	22.5 to 5.6 t	22.5 to 5.6 t 35.5 to 0.4 t lowering	25 to 5.6 t 40 to 1.6 t	25 to 5.6 t
Hoisting in m/min (two part line)	4th gear	–	–	–	–	50 to 2.8 t 80 to 0.7 t	50 to 2.8 t
	3rd gear	31.5 to 4.0 t	31.5 to 5.0 t 50 to 1.6 t	81.5 to 4.0 t	31.5 to 4.0 t 50 to 0.8 t lowering	31.5 to 4.5 t 50 to 1.3 t	31.5 to 4.5 t
	2nd gear	25 to 5.0 t	25 to 6.3 t 40 to 1.6 t	25 to 5.0 t	25 to 5.0 t 40 to 0.8 t lowering	20 to 7.6 t 31.5 to 2.2 t	20 to [illegible]9 t
	1st gear	11.2 to 9.5 t	11.2 to 9.5 t 17.7 to 1.6 t	11.2 to 9.5 t	11.2 to 9.5 t 17.7 to 0.8 t lowering	12.5 to 9.5 t 20 to 2.8 t	12.5 to 9.5 t
Hoisting in m/min (three part line)	4th gear	–	–	–	–	33.3 to 4.2 t 53.3 to 1.2 t	33.3 to 4.2 t
	3rd gear	21 to 6.0 t	21 to 7.5 t 33.3 to 2.4 t	21 to 6.0 t	21 to 6.0 t 33.3 to 1.2 t lowering	21 to 6.72 t 33.3 to 2.0 t	21 to 6.72 t
	2nd gear	16.7 to 7.5 t	16.7 t to 9 t 26.7 to 2.4 t	16.7 to 7.5 t	16.7 to 7.5 t 20 to 1.2 t lowering	13.3 to 11.4 t 21 to 3.4 t	13.3 to 11.4 t
	1st gear	7.5 to 12.0 t	7.5 to 12.0 t 12.5 to 2.4 t	7.5 to 12.0 t	7.5 to 12.0 t 11.8 to 1.2 t lowering	8.3 to 12.0 t 13.3 to 3.6 t	8.3 to 12.0 t
Gear shifting		manual control	manual control	manual control	manual control	remote control	remote control
Drive		three-phase current	D C	three-phase current	three-phase current	D C	three-phase current
Control		subsynchronous	Ward-Leonard[3]	eddy-current brake	eddy-current brake	Ward-Leonard	eddy-current brake

	Speed	Power[1]	Remarks
Slewing	1 rpm	5 kW (6.8 PS)	ball bearing race (Rothe Erde)
Jib luffing	63 sec total	17 kW (23 PS)	from min to max radius
Travelling	40 m/min	2 × 10 kW (2 × 13.6 PS)	min curve radius (inner rail) 7.5 m recommended rail type = S 49 or Preussen 8

Electrical Power Supply 380 V / 40 cycles

Hoist		permissable cable length[2] depending on cable cross-section		
		4 × 25 mm²	4 × 35 mm²	4 × 50 mm²
H 1 H 3 H 4	= 61 kVA	140 m	190 m	270 m
H 6	68 kVA	120 m	170 m	240 m
H 2 or H 5	79 kVA	110 m	160 m	220 m
recommended fuse (NH)		3 × 125 A	3 × 160 A	3 × 224 A

Weights and Reaction Forces

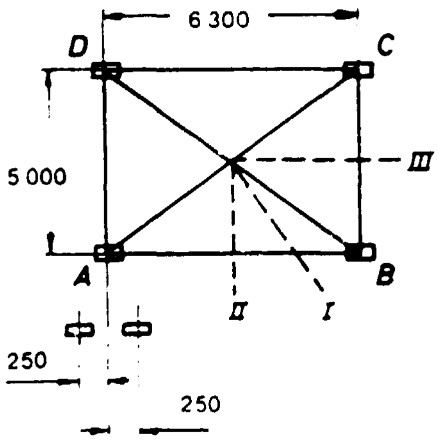
Crane weight[4] = 37 t
Counter weight ballast[5] = 32 t
Corner pressure (t)[4]

Crane out of operation
(Storm from the front)

Corner	position of jib		
	I	II	III
A	20.97	29.61	7.79
B	32.98	29.61	27.10
C	13.92	5.28	27.10
D	1.91	5.28	7.79

Crane in operation
(Wind speed ≤ 80 km/h)

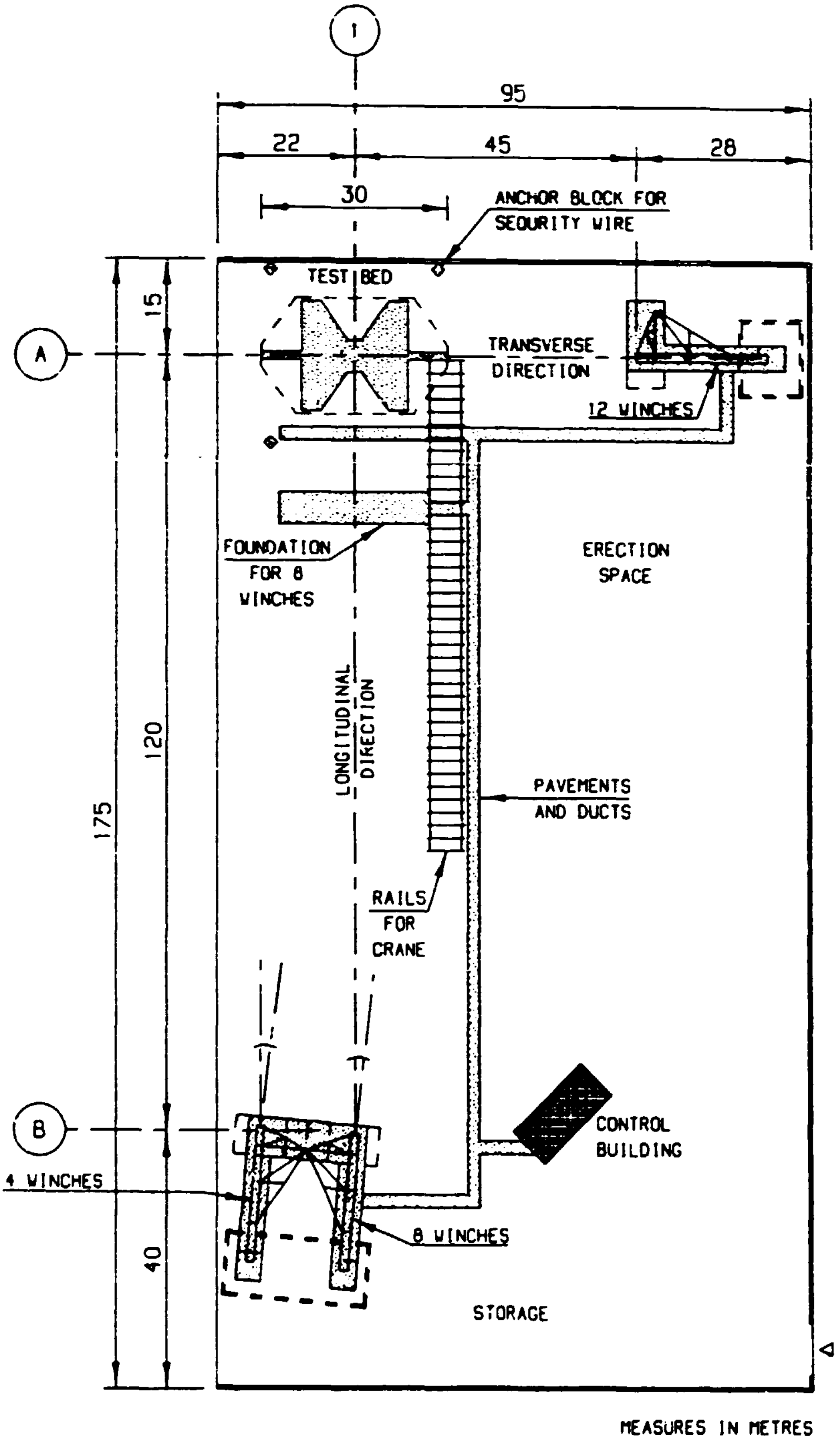
Corner	position of jib		
	I	II	III
A	19.77	19.07	7.30
B	31,53	28.90	18.60
C	16.23	16.94	28.71
D	4.48	7.11	17.41



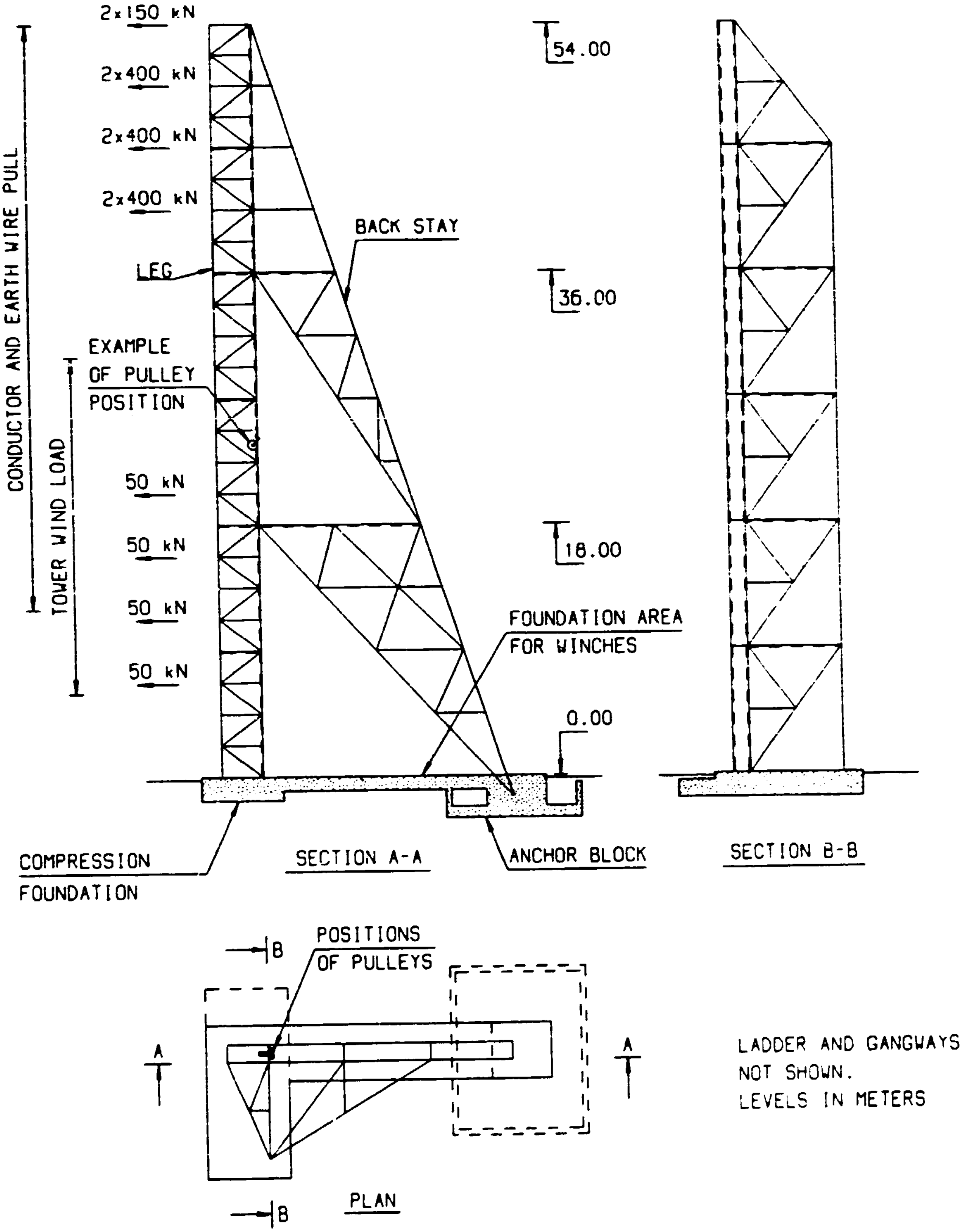
Horizontal force due to wind = 5,5 t

1) Three-phase slipring motor
2) According to VDE 0100/§ 41 N for movable cables and max 5% voltage drop
3) Power control by PEINER Field Weakening Control Unit
4) With jib L 5 and pivot point height of 46 m
5) See crane manual for ballast

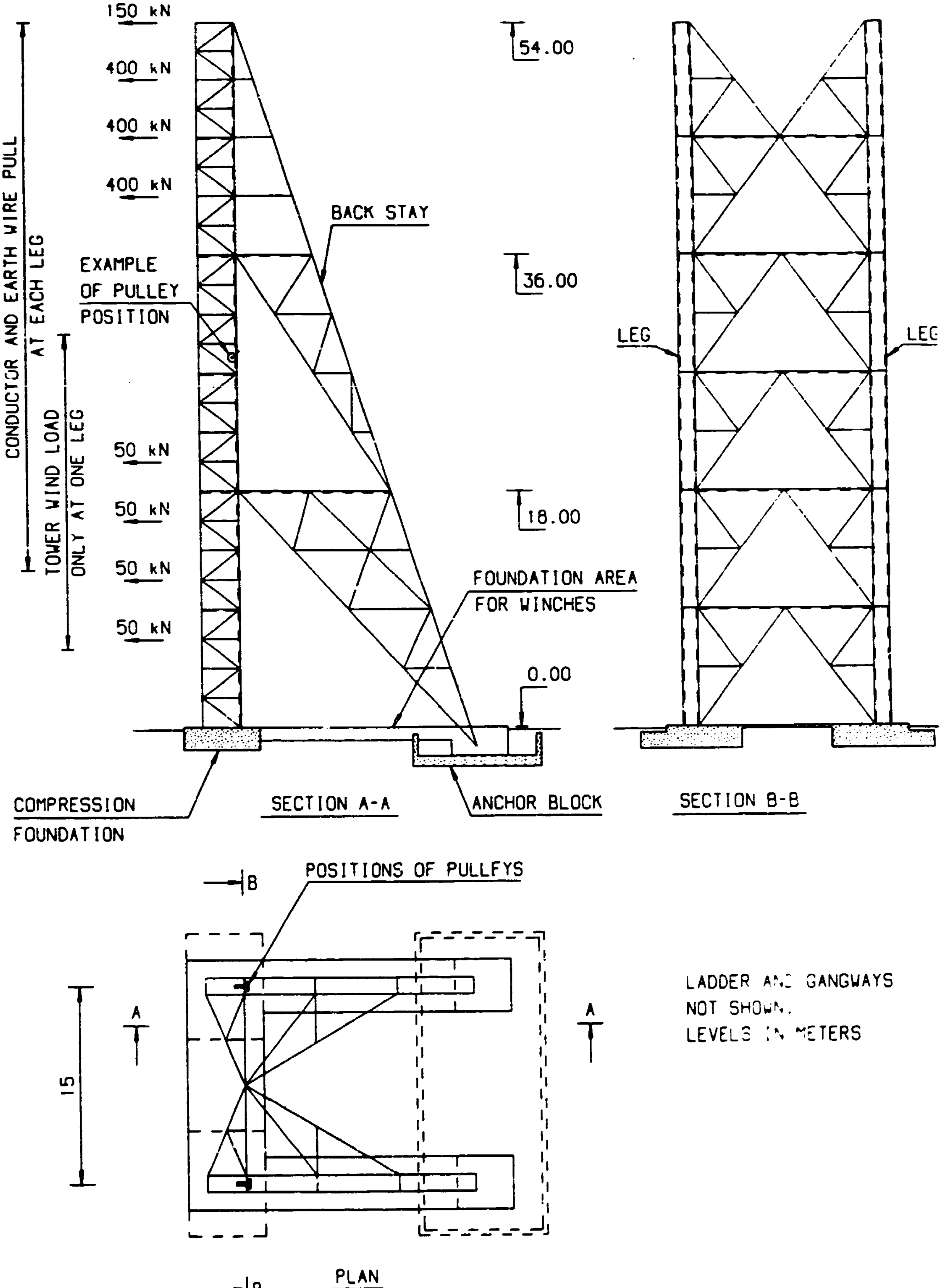
Subject to change without notice!



TOWER TESTING STATION
PROPOSAL FOR LAYOUT
1:1000

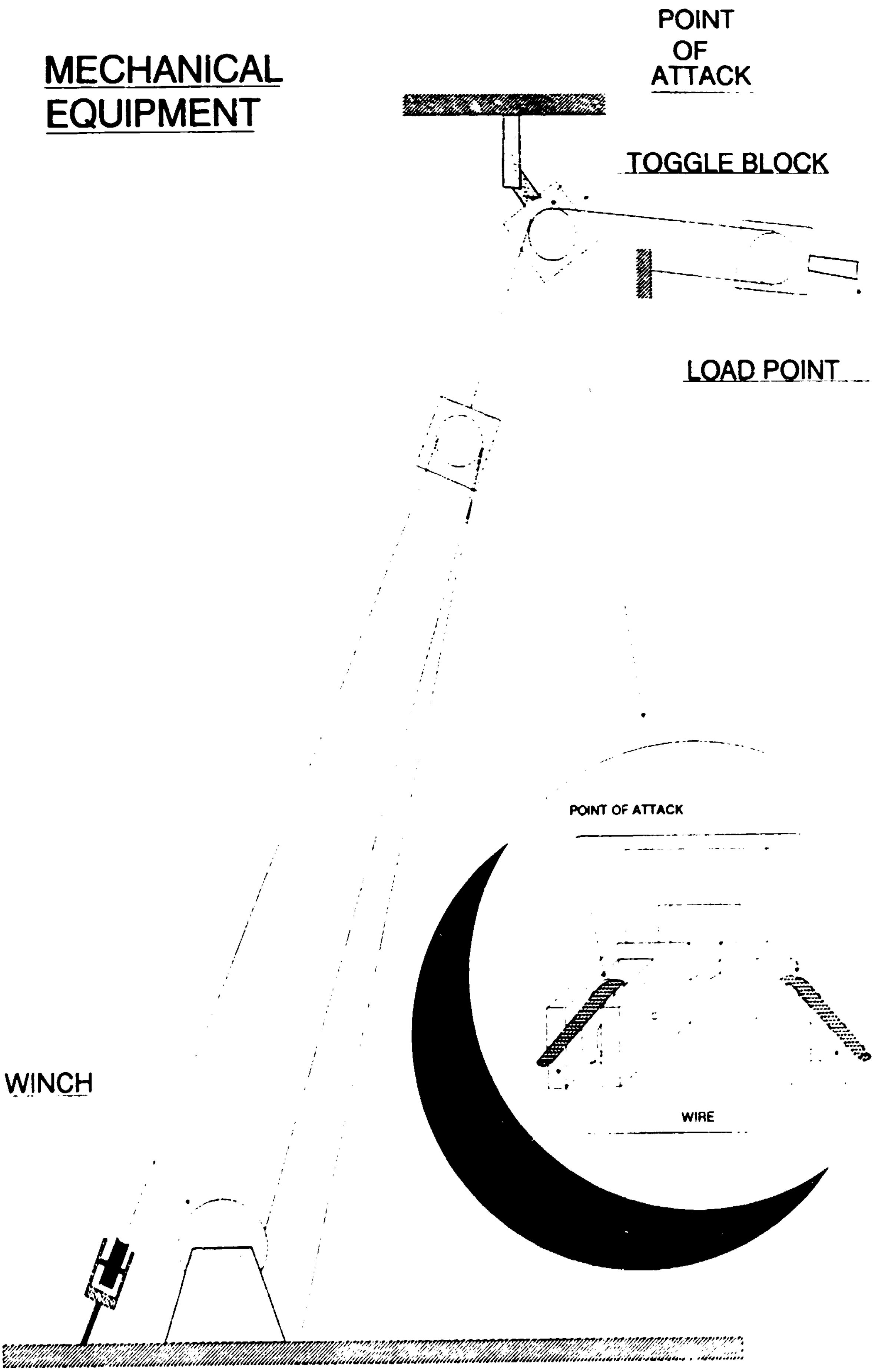


TOWER TESTING STATION
PROPOSAL FOR STEEL STRUCTURE AT LINE A
1:400

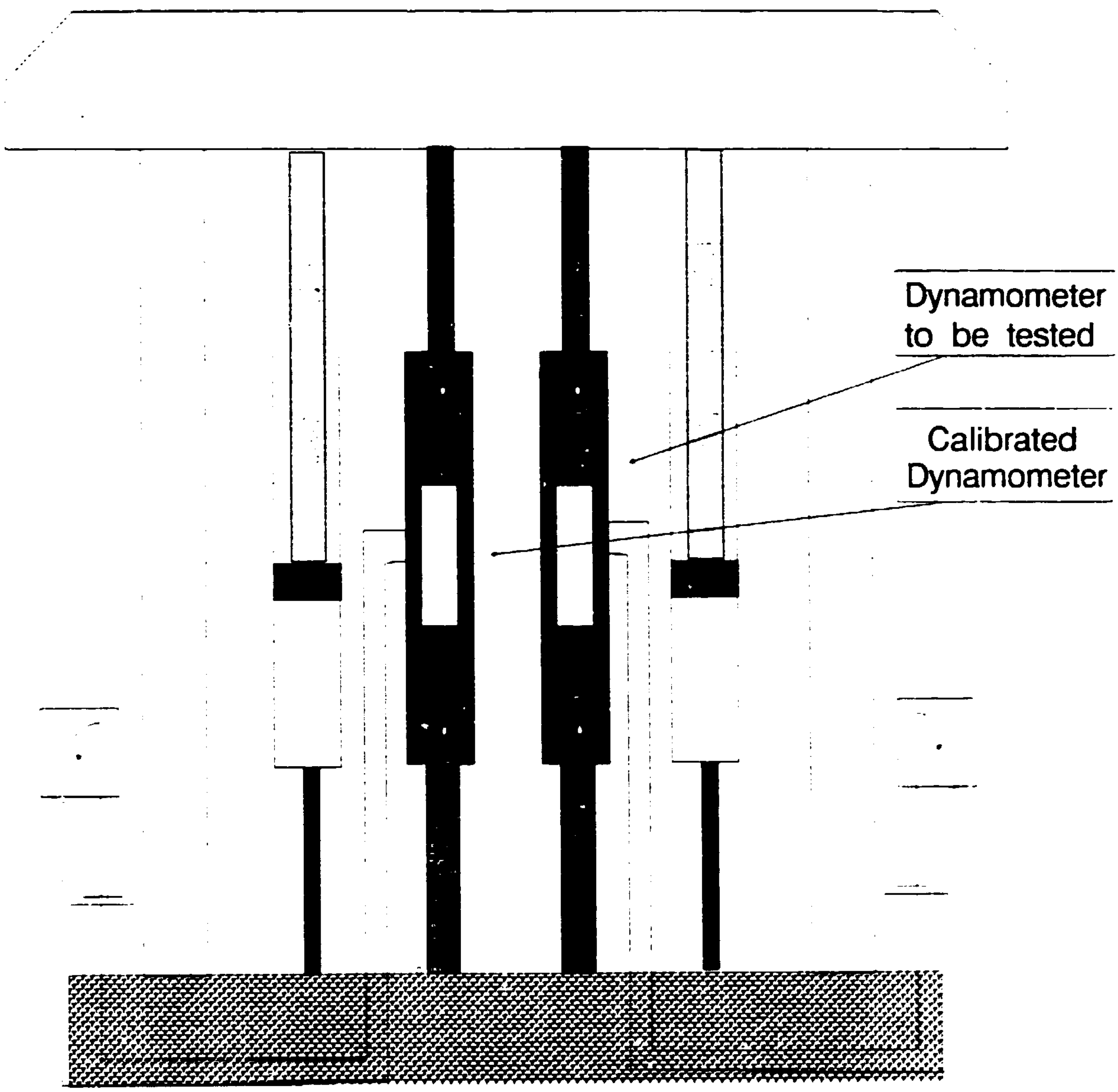


TOWER TESTING STATION
PROPOSAL FOR STEEL STRUCTURE AT LINE B
1:400

MECHANICAL EQUIPMENT

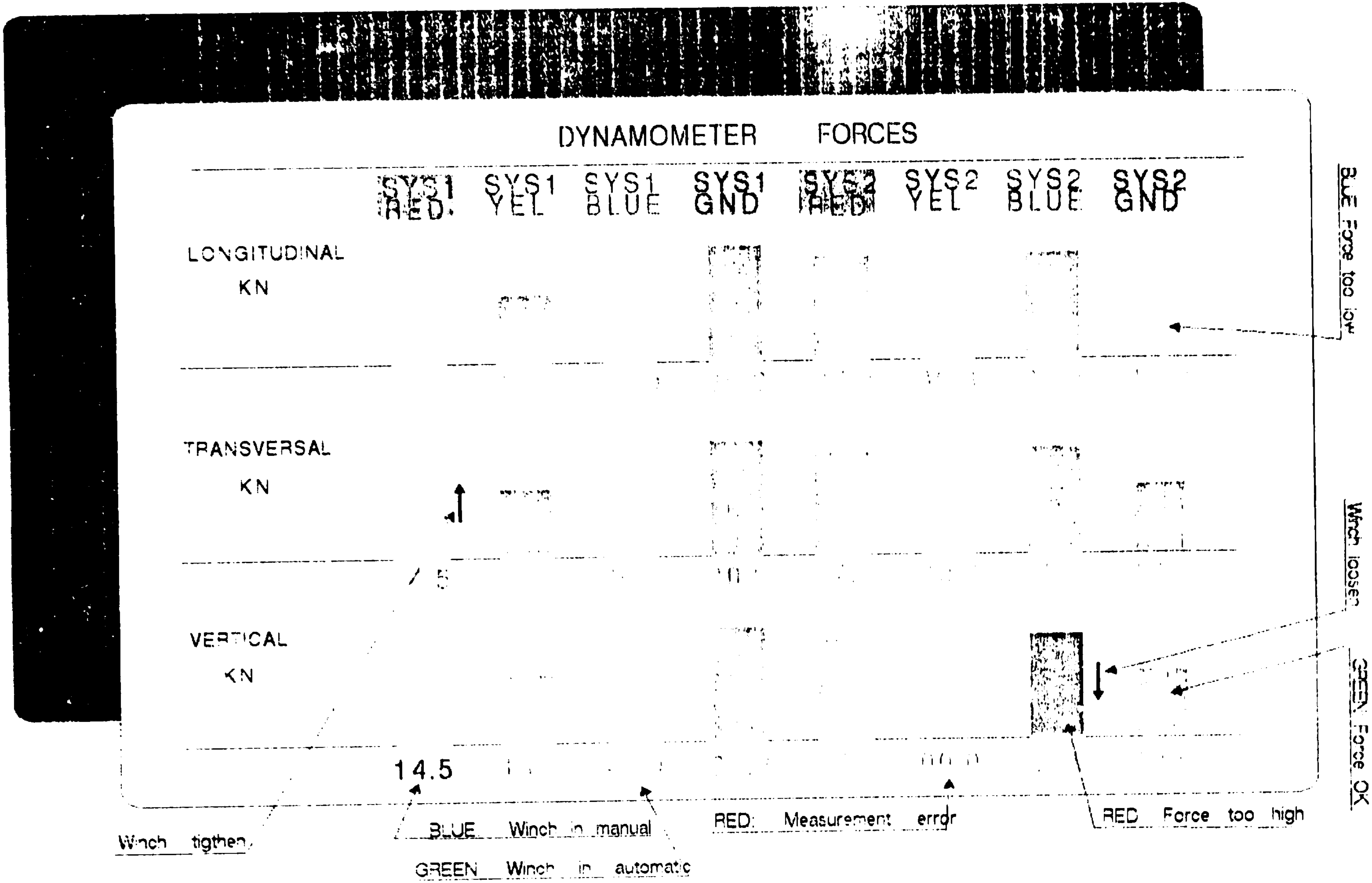


Testrig for dynamometer



Example of screen display

Annex



Example of test-data report.

TEST-DATA REPORT

METALCO TOWER TEST STATION

Type of tower tested:..

....

Name of tower manufacturer:....................................

....

Address of tower manufacturer:.................................

....

Name of tower designer:..

....

Address of tower designer:.....................................

....

Name of client:..

....

Address of client:...

....

Names of persons present during the test:......................

....

....

....

Example of test-data report.

DATE:.................. TIME:................

Load case:...

....

....

Load step:.........%

Wind speed:........m/s Wind direction..........deg.

Temperature.........deg. C.

(M: Winch in manual, **.*: Measure-error)

SPECIFIED LOADS

	SYS1 RED	SYS1 YEL	SYS1 BLUE	SYS1 GND	SYS2 RED	SYS2 YEL	SYS2 BLUE	SYS2 GND
Longitudinal (kN)	15.3	19.0	22.0	31.3	27.2	31.0	28.3	18.2
Transversal (kN)	15.3	19.0	22.0	31.3	27.2	31.0	28.3	18.2
Vertical (kN)	15.3	19.0	22.0	31.3	27.2	31.0	28.3	18.2

	WIND LOW	WIND MLOW	WIND MHIG	WIND HIGH
Longitudinal (kN)	2.0	2.0	2.0	2.0
Transversal (kN)	2.0	2.0	2.0	2.0

MEASURED RESULTING FORCES

	SYS1 RED	SYS1 YEL	SYS1 BLUE	SYS1 GND	SYS2 RED	SYS2 YEL	SYS2 BLUE	SYS2 GND
Longitudinal (kN)	15.6	19.2	21.8	31.1	27.4	31.2	28.3	18.0
Transversal (kN)	15.5	19.2	22.2	31.5	27.5	31.2	28.1	18.0
Vertical (kN)	15.1M	19.2	22.1	31.5	27.0	**.*	28.1	18.5

	WIND LOW	WIND MLOW	WIND MHIG	WIND HIGH
Longitudinal (kN)	2.0	2.0	2.0	2.0
Transversal (kN)	2.0	2.0	2.0	2.0

Example of test-data report.

MEASURED DYNAMOMETER FORCES

	SYS1 RED	SYS1 YEL	SYS1 BLUE	SYS1 GND	SYS2 RED	SYS2 YEL	SYS2 BLUE	SYS2 GND
Longitudinal (kN)	14.5	18.0	20.0	30.2	27.0	30.3	28.0	18.0
Transversal (kN)	14.5	18.0	20.0	30.2	27.0	30.3	28.0	18.0
Vertical (kN)	14.5M	18.0	20.0	30.2	27.0	**.*	28.0	18.0

	WIND LOW	WIND MLOW	WIND MHIG	WIND HIGH
Longitudinal (kN)	2.0	2.0	2.0	2.0
Transversal (kN)	2.0	2.0	2.0	2.0

DEVIATION SPECIFIED LOADS - MEASURED RESULTING FORCE

	SYS1 RED	SYS1 YEL	SYS1 BLUE	SYS1 GND	SYS2 RED	SYS2 YEL	SYS2 BLUE	SYS2 GND
Longitudinal (%)	-2.0	-1.1	0.9	0.6	+0.7	+0.6	0.0	1.1
Transversal (%)	+1.3	-1.1	-0.9	-1.3	27.2	-1.1	0.7	1.1
Vertical (%)	1.3M	-1.1	-0.5	-0.6	0.7	**.*	0.7	-1.6

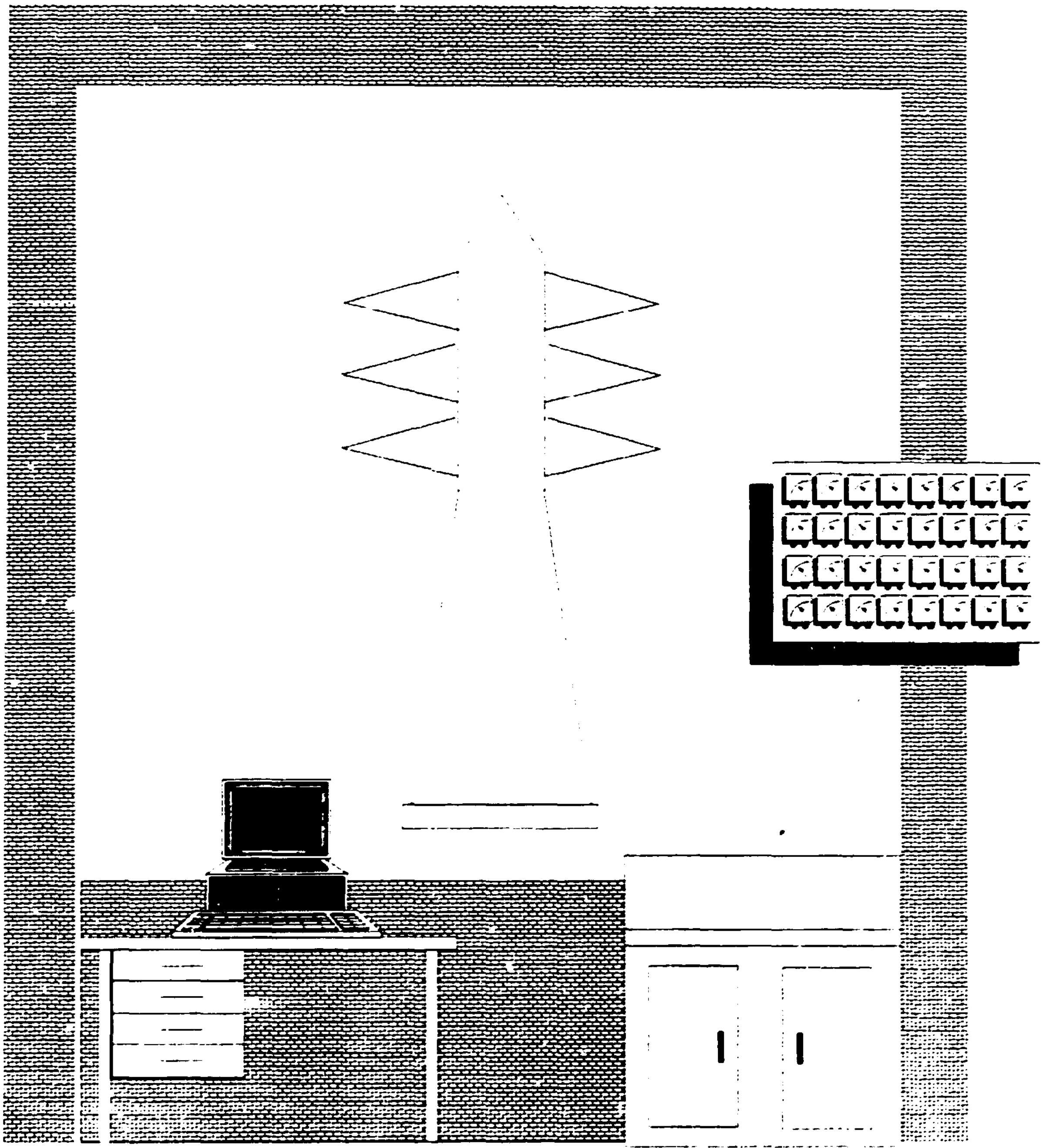
	WIND LOW	WIND MLOW	WIND MHIG	WIND HIGH
Longitudinal (%)	0.6	1.0	-0.5	0.2
Transversal (%)	0.3	-1.2	-0.7	1.0

DEFLECTIONS

	SYS1 RED	SYS1 YEL	SYS1 BLUE	SYS1 GND	SYS2 RED	SYS2 YEL	SYS2 BLUE	SYS2 GND
Longitudinal (mm)	154	178	201	168	170	216	135	123
Transversal (mm)	154	178	201	168	170	216	135	123
Vertical (mm)	154	178	201	168	170	216	135	123

(Page 2 and 3 are repeated with test-data from other load cases and load steps)

control room



Annex

PRICES OF EQUIPMENT AND COMPUTERS

The budgets are based on the rate of exchange on 13 February, 1990: 100 US$ = 645 Danish Kroner. All prices are in US Dollars.

Mechanical equipment:

Winches

Cable	Direction	Load Force	Line Parts	Line Pull	Price	No.	Total Price
Cond.	Long.	400	2+4	50	15,000	6	90,000
	Transv.	400	2+4	50	15,000	6	90,000
	Vertical	150	2+4	18.8	5,000	6	30,000
Gnd.	Long.	150	2+4	18.8	5,000	2	10,000
	Transv.	150	2+4	18.8	5,000	2	10,000
	Vertical	50	2	25	5,000	2	10,000
Wind	Long.	50	2	25	5,000	4	20,000
	Transv.	50	2	25	5,000	4	20,000

Winches purchase	280,000
Transport (5%)	14,000
Assembling + test	10,000
Total price winches	**304,000**

Steel wires

Cable	Direction	1st part Dia.	1st part Length	1st part Price	2nd part Dia.	2nd part Length	2nd part Price	No.	Total Price
Cond.	Long.	32	320	10	20	220	4	6	24,480
	Transv.	32	270	10	20	220	4	6	21,480
	Vertical	20	60	4	14	220	2	6	4,080
Gnd.	Long.	20	320	4	14	220	2	2	3,440
	Transv.	20	270	4	14	220	2	2	3,040
	Vertical	--	---	-	14	110	2	2	440
Wind	Long.	--	---	-	14	320	2	4	2,560
	Transv.	--	---	-	14	270	2	4	2,160
Security		20	100	4	--	---	-	6	2,400

Wires purchase	64,080
Transport (5%)	[illegible],200
Total price wires	**67,280**

Blocks

S: Number of sheaves

		1st part				2nd part				Total
Cable	**Direction**	**Load**	**S**	**Price**	**No.**	**Load**	**S**	**Price**	**No.**	**Price**
Cond.	Long.	400	1	6,500	6	200	2	3,000	6	57,000
						100	1	1,500	6	9,000
	Transv.	400	1	6,500	6	200	2	3,000	6	57,000
						100	1	1,500	6	9,000
	Vertical	150	1	2,500	6	75	2	1,200	6	7,200
						38	1	600	6	3,600
Gnd.	Long.	150	1	2,500	2	75	2	1,200	2	7,400
						38	1	600	2	1,200
	Transv.	150	1	2,500	2	75	2	1,200	2	7,400
						38	1	600	2	1,200
	Vertical	---	-	-----	-	50	1	800	2	1,600
Wind	Long.	---	-	-----	-	50	1	800	4	3,200
	Transv.	---	-	-----	-	50	1	800	4	3,200

Blocks purchase	168,000
Transport (5%)	8,400
Total price blocks	**176,400**
Winches	304,000
Steel wires	67,280
Blocks	176,400
Total price mechanical equipment	**547,680**
or approximately	**550,000**

Measuring equipment:

Dynamometers

Cable	**Direction**	**Load**	**No.**	**Price**	**Total Price**
Cond.	Longitudinal	400	6	7,800	46,800
	Transversal	400	6	7,800	46,800
	Vertical	150	6	5,500	33,000
Gnd.	Longitudinal	150	2	5,500	11,000
	Transversal	150	2	5,500	11,000
	Vertical	50	2	2,500	5,000
Wind	Longitudinal	50	4	2,500	10,000
	Transversal	50	4	2,500	10,000

Purchase dynamometers	173,600
Purchase total station	40,000
Purchase weather station	3,000
Purchase measuring equipment	216,600
Transport (5%)	10,830
Total price measuring equipment	**227,430**

Computer system

Hardware:

PLC	10,000
PC	15,000
Printer	2,000
Control desk	4,000
Instrumentation in control desk	8,000
Power stabilizer	3,000
Cables: 8 x (2 x 20 x 0.7) x 120 m	5,000
Cross fields	8,000
Security circuit	3,000
Hardware purchase	58,000
Transport (5%)	2,900
Assembling	7,000
Total price computer hardware	**67,900**

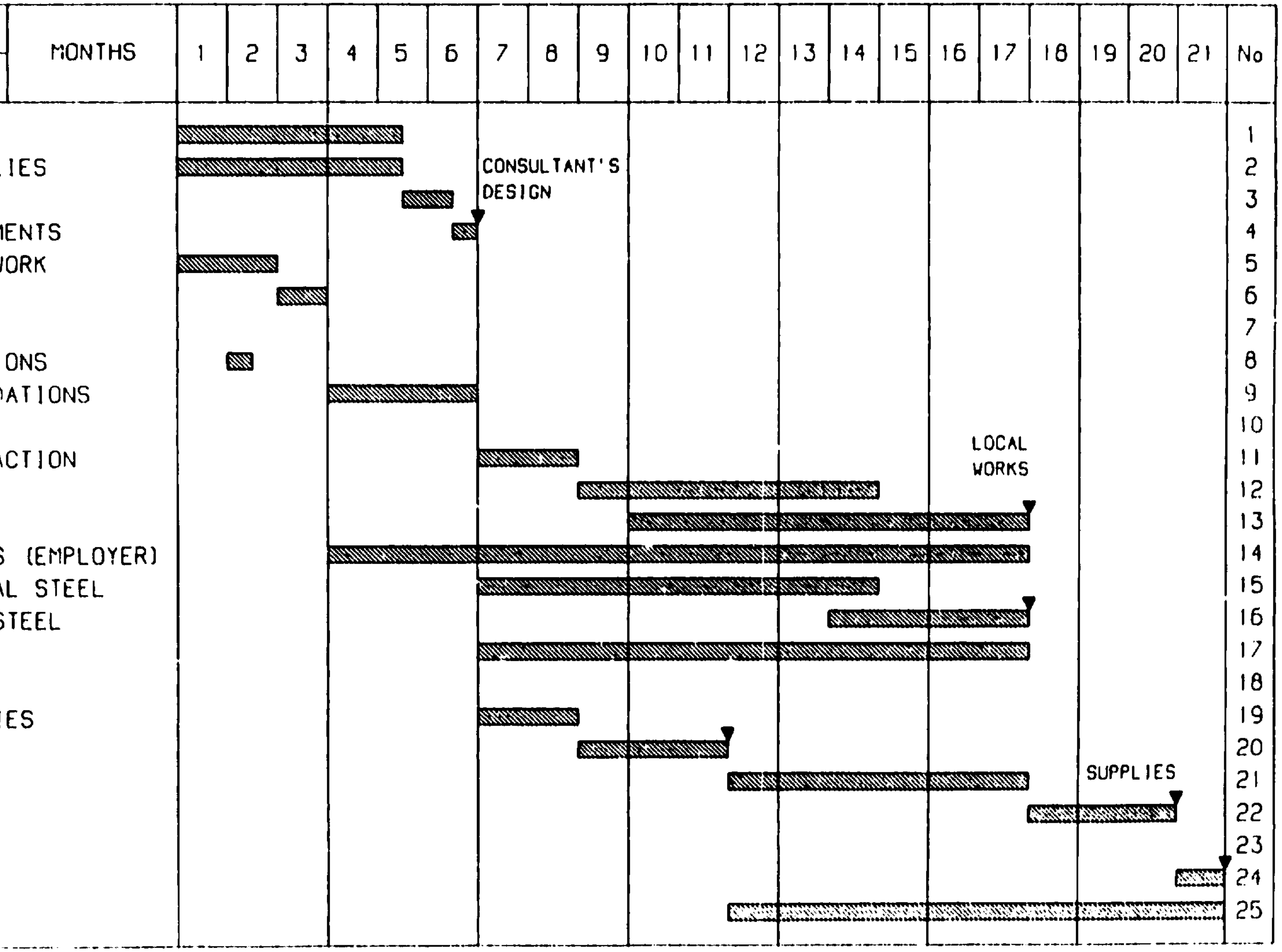
Software:

PLC, general	7,000
PLC, Winch control	15,000
PC	25,000
Total price computer software	**47,000**
Total price computer system	**114,900**
Test on site	10,000
Measuring equipment	227,430
Handling of subcontractor for measuring equipment (10% of 227,430)	23,000
Total price measuring equipment and computer system	**375,330**
or approximately	**380,000**

(The price of dynamometer test rig is not included in this budget)

TOWER TESTING STAT.ON. UNIDO POSTS DP/EGY/88/032/11-60 AND 63
TIME SCHEDULE. PROPOSAL OF FEBRUARY 1990.

No	ACTIVITY DESCRIPTION
1	DESIGN OF STEEL WORK
2	SPECIFICATIONS FOR SUPPLIES
3	REVIEW BY EMPLOYER
4	PRINTING OF TENDER DOCUMENTS
5	SPECIFICATION OF CIVIL WORK
6	REVIEW BY EMPLOYER
7	
8	GEOTECHNICAL INVESTIGATIONS
9	DETAILED DESIGN OF FOUNDATIONS
10	
11	LEVELLING OF SITE. COMPACTION
12	FOUNDATIONS. ETC.
13	CONTROL BUILDING
14	SUPERVISION. CIVIL WORKS (EMPLOYER)
15	FABRICATION OF STRUCTURAL STEEL
16	ERECTION OF STRUCTURAL STEEL
17	SUPERVISION. STEEL WORK
18	
19	TENDER QUOTATION. SUPPLIES
20	AWARD OF CONTRACTS
21	FABRICATION. TRANSPORT
22	INSTALATION
23	
24	COMMISSIONING
25	SUPERVISION OF SUPPLIES



Annex