

[1 STRICTLY CONFIDENTIAL]

LANGUAGE SUBFOLDER

VP/WG JAN 2015

PLEASE RETAIN
ORIGINAL ORDER

UN ARCHIVES

SERIES	<u>5-19/7</u>
BOX	<u>27</u>
FILE	<u>6</u>
ACC.	<u>TE 323/1</u>

NATIONS UNIES

COMMISSION ÉCONOMIQUE
POUR L'EUROPE

ОБЪЕДИНЕННЫЕ НАЦИИ

ЭКОНОМИЧЕСКАЯ КОМИССИЯ
ДЛЯ ЕВРОПЫ

UNITED NATIONS

ECONOMIC COMMISSION
FOR EUROPE

Training and Fellowship Programme Section,
Office of Technical Co-operation, New York



RECORDS CONTROL

EC 419741

21 November 1974

TC Country file

18 323/1 POLA

*With the compliments
of the Technical Assistance Office
of the Economic Commission for Europe*

For your information.

UNITED NATIONS

TECHNICAL ASSISTANCE OFFICE

ECONOMIC COMMISSION FOR EUROPE

Name and home country: MILEWSKI, Mr. L.A., Poland

Field of study: Data base systems

Country(ies) of study: United Kingdom

Date of award: 15 August 1974 - 16 November 1974

Birmingham, November, 1974.

FINAL REPORT

Written by U.N. TAO Fellow studying in United Kingdom

I. Basic Formal Data:

1. Name of Fellow:

Mr. Lech. A. Milewski, M.Sc.

2. Job Title:

Head Designer of Systems and Organisation.

3. Name and Address of Employer:

Office for Information Systems
Design and Organisation Consulting in Building Industry
"ETOBSYSTEM", Warszawa, ul. Brylowska 8A, Poland.

4. Study carried at:

Standards Associates Systems Consultants Limited,
Neville House, 14, Waterloo Street, Birmingham. B2 5TX
England.

5. Time of study:

15.08.1974-16.11.1974.

6. Subject of Study:

Data base systems

7. Under supervision of:

British Council, London.

II. Statement concerning fellow's previous experience and responsibilities at home country:

1. Education:

Warsaw Polytechnic (1958-1964) in mechanical engineering, industry management and organisation.

2. Basic steps of personal career:

- a) 1963-1966 Production control engineer in ZELMOT - automotive electric equipment manufacture.
- b) 1971-1972 Senior system designer (ETOB - Building Industry Computer Centre) - ICL application software development and implementation (PERT, DMS, Linear Programming, FIND-2)
- c) 1972- Head Designer of Systems and Organisation (ETOBSYSTEM). Manager of Data Base System design and programming.

The above system has been completed and successfully applied in the Ministry of Building for all country project planning system and in some organisations for various information systems.

3. Lectures and publications:

The fellow has held numerous lectures concerning data processing systems at his home organisation, Warsaw Polytechnic and various building companies.

In June, 1973, fellow held a lecture at a conference on "Profitable Computer Applications in Building Industry" organised by International Business Communication in London.

Some articles have been published by fellow in Polish technical journals.

III. Statement concerning problems fellow's home organisation should have solved in the near future with help of research study undertaken by fellow:

Fellow's home organisation (ETOBSYSTEM) as a member of Building Industry Computer Centre (ETOB) is responsible for research works, management information systems design and implementation as well as for customer organisation and method study and consulting. Three main areas of ETOBSYSTEM are:

- individual project planning and control (main huge building projects in Poland are supported and aided by ETOBSYSTEM)
- management information system for building enterprise
- national-wide information systems based on integrated data-bank containing information about projects, resources, enterprises, etc. (first successful effort in this area has been done by installation of data-base system - look at II.2.d)

For successful completion of above problems the following main objectives should be obtained in near future:

1. To increase the degree of organisational and topical complexity of computerised systems to be implemented in the building industry.
2. To set up multi-level information system for the Ministry of Building.
3. To organise proper data-banks for use of individual project, building enterprises, regional and branch ^{union boards} and Ministry of Building.
4. To develop existing data-base system providing modern direct-access techniques, real-time and multi-access facilities.
5. To support the supervising organisation (ETOB) in proper choice design and implementation of planned computer network (direct access devices, data-terminals, tele-processing, operating systems, application software and associated organisational methods).

The study undertaken by fellow has been associated with all the above mentioned points (1-5)

IV. Statement concerning host organisation of study:

Standards Associates systems consultants Limited is an independent company of computer systems consultants with its headquarters in Birmingham, England. The company was formed in February, 1968, by a group of computer professionals from various computer manufacturers, bureaux and users.

Since its creation, Standards Associates has concentrated on two main areas of activity:

computer systems development and consultancy systems, programming and management/user staff training and education.

All Standards Associates' work is based on the acceptance of a contracted, or sub-contracted, method of operation, which allows clients to retain complete control over any project for which they employ Standards Associates.

Major projects recently completed, or in progress, within the two main areas of activity give some indication of the size and scope of Standards Associates' activities:

The production of the National Computing Centre's latest version of their "Basic Systems Analysis Training Package". This "package" is being used as the basis of training of systems staff by some 250 organisations in the U.K. and Overseas.

The development and presentation of a series of systems analysis and design courses for computer staff of the British Steel Corporation.

Training consultancy to determine and implement the training needs of the data processing staff of a major U.K. insurance company.

Systems development and implementation of a large computer bureau based planning and control system for the construction and engineering industries.

Organisation, development and presentation of International Fellowships in computer programming and systems analysis and design, for students from developing countries, in conjunction with the British Council.

The development and presentation of some 40 systems courses, of various levels and content, for the Dunchurch Industrial Staff College, a division of the U.K. General Electric Company.

Design and implementation of systems standards of methods and documentation for a major U.K. insurance company.

The presentation of some 25 systems courses for International Computers Limited in the U.S.S.R., Czechoslovakia, Poland, Yugoslavia and Hungary.

The presentation of a series of systems analysis and design courses for the Civil Service College, the training centre of the U.K. Government Civil Service Department.

Apart from having studied at Standards Associates, fellow has visited:

1. International Computers Limited Customer Training Centres at Beaumont, Hedsor Park and Radley House (London), where he has attended five courses.
2. National Computer Centre and Post Office joint course on Data Communications Systems at Scalford Conference Hall near Melton Mowbray.
3. Management Systems and Programming Limited - a well known independent software house. Fellow took part in a seminar concerning data base systems actually developed by M.S.P.

V. Statement covering the programme of observations and study:

Programme of training has been covered by a range of courses, practical exercises, presentations, discussions and self-teaching manuals. Main areas of training attended by fellow are listed below:

1. An introduction to information systems course (run by Standards Associates, based on self-teaching manuals and films from Edutronics). The course has covered the following problems:
 - system concept and terminology (structure, hierarchy, environment)
 - physical systems (materials, facilities, products)
 - information systems (goal-direction, up-to-date information, monitoring performance, accurate information)
 - system delays and their effects on organisation response
 - planning and accounting on information systems
 - communication in the system
 - information cycle, planning cycle
 - organisation performance and environmental changes.
2. System theory course (run by Standards Associates, based on films and materials from Edutronics). The main areas:
 - the systems approach model (define objectives, plan alternatives, analyse, design, implement, evaluate /test/). The importance of feedback.
 - defining systems objectives (needs, goals and objectives of the system, known output requirements, constraints, statement of intent, observable and measurable attributes)
 - planning (use of tree diagrams, mutually exclusive alternatives, output - alternative plans)

- analysis (objectives of analysis, planning alternative strategies, designing an effective strategy, documenting a strategy, evaluating a strategy; gathering information about the system, organising information about the system, verifying information about the system, a quantitative model, evaluating feasible alternatives)
- design (design objectives - functional, effective, efficient, simple, easy to build, easy to evaluate; design planning - define outputs, data collection strategy, developing alternative design plans; design analysis - separating plans into logical parts, evaluating alternative designs, selecting the best alternative; design specifications - output requirements, input requirements, processing requirements; documenting design specifications - detailed processing specifications; design evaluation - satisfaction of goals, satisfaction of strategy, effectiveness and efficiency, simplicity and complexity, ease of building and evaluation)
- implementation and evaluation (tests)

3. Hardware/Software Revision, Introduction to Advanced Systems (systems course run by Standards Associates). The main areas:

- information representation
- systems architecture
- multiprogramming
- multiprocessing
- real-time systems
- multiaccess
- time-sharing
- ancillary equipment (documents bursting, decollating, trimming, copying)
- operating systems
- utility software
- application software
- system design considerations/core requirements, files selection, file security, errors, system back-up, economics of security

4. National Computing Centre systems documentation standards

Many working hours have been spent on looking through these standards. Fellow has received own copy of NCC documentation standards which may be very useful at home organisation. Fellow took part in final stage of system design course which enabled him to appreciate practical use of NCC documentation.

The basic contents of NCC standards are as follows:

- documentation control (referencing, cross-referencing physical filing and control, registration of names, amendment handling)

- communication (rules for preparation and layout of text, management reports, data processing internal documents, user department documents, recording facts and agreements)
 - procedures (use of procedure charts and decision tables, symbols and conventions for flowcharting, types of charts, decision tables)
 - data (files, records and item documentation)
 - relationships, interactions (organisational charts, grid charts)
 - appendices (the standard forms, the standards related to project phases, cross-references in the manual, index and glossary of terms).
5. Management Information Systems (run by Standards Associates, based on Edutronics manuals and video tape). The main areas:
- system structure (one-to-one, pyramid, inverted pyramid)
 - management as process of decision-making
 - MIS design (organisation model, basic system concept, principles of information processing, environmental factors, resource management)
 - approaches to design MIS (traditional, decision theory, functional, process, information flow)
 - design techniques (decision centres, documents flow, information channels, input-output)
 - motivation (Maslow's hierarchy of human needs, models of leadership)
6. Direct Access Files Techniques (run by Standards Associates, based on Edutronics films and manuals). The main areas:
- file parameters (volatility, activity, frequency, size, growth)
 - sequential files (binary search technique, skip technique)
 - direct files (key transformation techniques)
 - index-sequential files
 - timing.
7. Data Base Organisation (run by Standards Associates, based on Edutronics films and manuals). The main areas:
- list structured files
 - ring structured files
 - advanced file structure
 - tree structured files
 - threaded list files
 - inverted files
 - file usage elements and considerations

8. Data Communications (run by Standards Associates, based on Edutronics films and manuals). The main areas:

- criteria of data communication system (function, volume of data, urgency, accuracy, cost).
- transmission mode and parameters
- network design
- programming concepts (IBM facilities - QTAM, TCAM, BTAM, EXCP)

9. Advanced Data Organisation Course - run at ICL Customer Centre at Beaumont. The main areas:

- chained files (single, two-way, ringed)
- tree structure (chained files, PLUTO files, generalised files)
- inverted files (vector lists, ~~but~~ arrays)
- data base techniques (file handles, data management systems, file transparency, data dictionary)
- creation and maintenance of data base (consistent data, derived files, time and data base)
- personnel to run data base (data co-ordinator, data specialist, data clerks, programmers)

The theory was reinforced by a large number of exercises.

10. Financial Management Course - run by Standards Associates. The main areas:

- financial model of an enterprise
- duality of financial events
- use of capital
- cost accounting
- analysing a project/project simulation
- decision trees

11. VS - virtual store concept (run by Standards Associates, based on Edutronics films and manuals). The main areas:

- VS concept (block relocation, page relocation, segment relocation)
- DOS and VS comparison
- VS macro instructions
- Job Description Language

12. Data Communication Systems - course run by NCC and Post Office at Scalford Hall near Melton Mowbray. The main areas:

- commercial applications and justifications of data communication
- principles of data transmission
- Datel services (in U.K. and international)
- data communication devices (modems, multiplexors, concentrators, terminals, front-end processors)
- line control and error detection
- network design
- advanced transmission technology
- file organisation for data communication
- man-machine dialogue design
- basic queueing theory
- system reliability and security
- running systems presentations by Trustee Savings Bank and LACES (London Airport Customers Services)

Course lectures were supported with practical exercises.

13. Real Time Systems Course - run by ICL at Hedsor Park. The main areas:

- ICL - 1900 hardware associated with RTS (VDU terminals, termiprinters, communication control units, scanners, selectors, remote batch processors, communication processors)
- ICL - 1900 software available for RTS
- main application areas
- system recovery techniques

The theory was reinforced with practical exercises.

14. Managing Projects course - run by Standards Associates. The main areas:

- project method (project stages, need for planning, risk elements)
- planning techniques (bar charts, networks)
- project estimating (units of work, complexity, standards)
- project control
- people management

The course was supported with very interesting and valuable case studies and simulation games.

15. DRIVER Programming course run by ICL at Radley House, London.

The course has enabled Fellow to write his own real time programs using Driver facilities and to organise properly programming work in real time systems.

16. NIMMS Data Management System course - run at ICL Training Centre at Beaumont. Basic objectives of the course:

- describe the design aims and concepts of NIMMS
- describe the concept of data base
- design of PLUTO and Generalised files structures
- describe the major functions of a Data Management System
- describe the major functions of File Handler and how it derives Logical Files from the Physical Data Base.

17. Advanced Real Time System Course - run by ICL at Beaumont Training Centre. Basic objectives of the course:

- recognise and describe the critical areas in real-time system
- problems of queueing with particular reference to file structure
- techniques used in timing the message path in time critical system
- simulation techniques

18. Special application problems concerning building industry.

Fellow had an opportunity to be familiarised with data processing system used in Swedish construction company "BYGG"-ADB". Detailed notes concerning this system have been sent to Fellow's home organisation.

VI. Fellow's evaluation of training:

1. Standards Associates as host organisation of the training has helped fellow very much in gaining all benefits of the study. The choice of courses and their sequence - very good. Courses run by Standards Associates complemented courses of other organisations - type and methodology of training - very modern. Very competent and cheerful staff have taken care of various fellow's problems and enabled to concentrate only on studies.
2. The programme of training was very well designed; modular approach to educational topics is strongly appreciated by fellow.
3. Fellow has collected many very valuable materials. He will use these materials at home organisation for organisational and designing purposes.

4. Comparing actual level of computer technology and applications in fellow's home organisation to those studied during the training, it is possible to specify main areas of study implementation:

- new approach to system design (data base approach, higher degree of data and file complexity)
- advanced direct access file techniques
- new approach to programming (modularity, operating systems facilities, remote processing details)
- real-time systems (new devices, new data-processing technology, new dimension of security, reliability, privacy problems)
- new approach to team-work organisation and management.
- need for designing and programming standards and documentation
- modern educational techniques.

5. The study was very intensive, in many cases a training load was over 12 working hours per day. Three months period of time was enough only for theoretical training.

In the case of data processing systems, which deal with both software and hardware, it is very important to gain some practical experience working with computer installations which are not yet available at fellow's home country.

Fellow applied for extension of training for such purpose but unfortunately it was not accepted.

Fellow's recommendation for such type of training is to provide an amount of practical work at least equal to educational period.



NATIONS UNIES
COMMISSION ÉCONOMIQUE
POUR L'EUROPE

ОБЪЕДИНЕННЫЕ НАЦИИ
ЭКОНОМИЧЕСКАЯ КОМИССИЯ
ДЛЯ ЕВРОПЫ

UNITED NATIONS
ECONOMIC COMMISSION
FOR EUROPE

Mrs. M.J. Shoukletevich

Training and Fellowship Programme Section
Office of Technical Co-operation, New York



JAN 7 1975

TE 323/1 POLA

*With the compliments
of the Technical Assistance Office
of the Economic Commission for Europe*

29 July 1974

TECHNICAL ASSISTANCE OFFICE
Economic Commission for Europe
UNITED NATIONS

Date of award:

5 January to 6 July 1974

Name and home country:

Mr. Julius I. CIESLA (Poland)

Field of study:

Bridge Building

Country (ies) of study:

the United Kingdom

JULIUSZ CIESLA, M.SC.

PAWINSKIEGO 29 m 76

02-106 WARSZAWA

POLAND



FINAL REPORT

ON STUDY IN THE UNITED KINGDOM

SUBJECT OF STUDY: TECHNOLOGY OF PRESTRESSED CONCRETE
IN INDUSTRIAL BRIDGE BUILDING

PERIOD OF STUDY: 6TH JANUARY - 10th JULY 1974.

FINAL REPORT

On the study in the United Kingdom

Subject of study: Technology of Prestressed Concrete in Industrial Bridge Building.

Period of study: 6th January -10th July 1974

.....

1. Introduction

I am a Civil Engineer specialising in bridge building. I have graduated from the Civil Engineering Department of the Technical University of Warsaw in 1959 as "magister engineer" (equivalent of M.Sc.) I then worked as a lecturer in the same Department, then as a Civil Engineer with a building firm. Since 1961 I have been working at the Road Research Laboratory at the Ministry of Transport in Warsaw. I am the Head of the Concrete Bridge Section of the Bridge Division at that Laboratory.

The range of my activities comprises research and development work on concrete bridges, especially prestressed concrete bridges. I was carrying out research on new types of prestressed concrete bridges. As a result of tests recommendations for designers and building firms were made.

I supervised the construction of some prestressed concrete bridges.

I have written some papers, e.g.
"Control of steel for prestressing", "Influence of the bond between prestressing tendons and concrete on ultimate moment of pretensioned girders", "Big prestressing cables".

I was one of the authors of the "Draft Code of Practice for Prestressing Works for Bridges" and Draft Code of Practice for the Design of Concrete Bridges".

I am a member of the Polish Society of Civil Engineers. A list of my publications was attached to the application form for the United Nations Fellowship.

The development of the Polish economy by industrialisation of the country and modernisation of agriculture requires rapid improvement of the transport system. This requires not only the building of new roads but also the increasing weight of vehicles and the increase in traffic require the modernisation of the existing system of roads and engineering structures. Therefore in Poland a large number of new bridges are required to cross rivers, railways and other obstacles. Also the Polish Railway require a large number of new bridges to replace old, unsuitable bridges.

In Poland most of the bridges that have to be built are small and middle span bridges. That fact and the large demand for steel in many branches of the economy obliges us to save on it in buildings. This situation favours concrete bridges, especially prestressed concrete bridges. To avoid traffic obstruction during the time of construction, which is very inconvenient and also very costly, new bridges have to be built quickly using modern technology and equipment. One of the most important ways to achieve this aim is the mechanisation of works on the building site and the use, where suitable, of precast members produced on a large scale using industrial methods.

The aim of the Fellowship was to study the possibility of the industrialisation of prestressed concrete technology in bridge building and to study current British research in this field.

2. Programme and course of study

The study was arranged by the British Council at the Concrete Structures Section of the Civil Engineering Department of Imperial College of Science & Technology for three months. The programme of study was established by the Head of the Concrete Section, Professor A. J. Harris. As the three-month period appeared to be too short for the study of the above-mentioned problems, Professor

Harris applied to the British Council for an extension for another three months. So the whole period of the study was six months.

The study programme was:

Active participation in experimental work being carried out in the Concrete Structures Laboratory, Department of Civil Engineering, Imperial College.

Study of technical reports of the Concrete Structures and Technology Section, Imperial College.

Visits to other research establishments, e. g. Cement & Concrete Association, Transport and Road Research Laboratories, Building Research establishments.

Visits to Contractors producing precast prestressed concrete members for bridges.

Visits to design offices to discuss precast prestressed concrete members for bridges.

Visits to design offices to discuss present trends in Britain in the use of industrial methods in bridge construction.

The above programme was realised in the period of six months.

In that short time I have taken part in research on concrete box-girders under eccentric loading and in research on the bond between concrete and steel under static loading, including the effect of repeated loading and unloading. All the above-mentioned tests were made at the Concrete Structures Laboratory.

Simultaneously I have been studying technical reports of research that has been carried out in the Concrete Structures Department. When I visited the Cement and Concrete Association, Transport and Road Research Laboratory and Building Research Station I was told about their most recent research.

I visited and had discussions with:

The Ministry of Transport at the Department of the Environment.

The Bridge Section of British Rail.

Dow Mec Concrete Ltd. in Talkington, Market Deeping, Lincs, which is one of the biggest factories in the U.K. producing precast prestressed concrete members for bridges.

Ove Arup & Partners, Consulting Engineers, involved with the design of a large number of bridges in U.K. and abroad.

PSC Equipment Ltd., in Iver which is a factory producing prestressing equipment.

Prestressed Concrete Division at CCL Systems Ltd., in Surbiton, Surrey, which is a firm involved with the technology of prestressing.

Bridon Wire Ltd., in Doncaster, Yorkshire, a factory producing wires and strands for prestressing, including coated strands.

Some building sites and bridges.

3. Important research carried out at the Concrete Section of Imperial College, Cement and Concrete Association and Transport and Road Research Laboratory.

Prestressed concrete box-girders are being used increasingly in bridge construction because of their favourable structural action in carrying eccentric loads and their ability to absorb bending moments of alternate algebraic sign. The structural behaviour of box-girders under eccentric loads has been studied extensively in the theoretical field. Whilst many analytical procedures have been proposed, very little experimental work has been reported. The majority of the tests that have been carried out are concerned with working load conditions in models made of materials other than concrete. The need for experimental research on prestressed concrete specimens is evident.

Tests have been carried out by Mr. R. Danesi as a project leader and Professor A. L. L. Baker and Dr. A. D. Edwards as supervisors. Three large-scale prestressed concrete box-girders, without interior diaphragms, simply supported but torsionally restrained at both ends, have been tested to failure under eccentric loads. The specimens were of rectangular single-cell cross-section and are of the following dimensions: length - 8320 mm, depth - 500 mm, breadth - 700 mm, flange thickness - 50 mm, web thickness - 50 mm, 75 mm and 125 mm (constant for each beam). The web thickness was thus the only parameter to be varied.

They have studied the following problems:

The behaviour up to failure of prestressed concrete box-girders of deformable cross-section

The significance of distortional deformations and their effect upon the overall structural response, in prestressed concrete box-girders of practical proportions

The determination of the effects of cracking upon flexural torsional and distorsional stiffness, in order to establish the degree of safety against these structural actions produced by eccentric loads

Modes of failure and crack patterns which could lead to the development of a limit state design procedure

Data for comparison with available analytical methods to check the validity of their idealizations and to establish limits of applicability.

Box-girders of deformable cross-section, i. e. either without any or without enough interior diaphragms, when subjected to eccentric loads undergo not only warping but also distortion of the cross section. As a consequence, in addition to longitudinal warping stresses, transverse flexural stresses arise. The magnitude of these stresses depends mainly upon the thickness/width ratio of the flanges and webs.

All the box girders were designed in a standard way. It means that prestressing tendons were designed for bending. Shear and torsion were taken by non-tensioned reinforcement. No reinforcement was designed for distortion which took place due to lack of intermediate diaphragms. It appeared that the best in regard to distortion was the girder having a web thickness of 75 mm (the second girder). The first distortional crack occurred at 75% of permissible load for that box-girder. At 100% permissible loading distortional stiffness was 35% of stiffness uncracked section. For the other two girders these values were less. For example, in the case of the third girder having web thickness 125 mm, the first crack appeared at 62.5% of permissible loading and distortional stiffness was only 15% of stiffness of the uncracked section. For the first girder having web thickness 50 mm, the first crack also appeared at 62.5% but distortional stiffness was 30% of the stiffness uncracked section, that is almost as much as for the second girder. The value of maximal sustained loading for the first girder was 175%, for the second 185% and for the third girder 212.5% of permissible loading. The general conclusion from this research was that the standard design method, using simple superposition did not appear to be sufficient for box-girders. One of the most interesting research projects being carried out at Concrete Structures Section is research on bond under

static repeated and fatigue loading. These tests are being carried out by Mr. P.J. Yannopoulos and Dr. A.D. Edwards. Basic data are derived from short reinforced concrete tensile specimens (38 mm length) with central 16 mm deformed bar. The specimens are loaded vertically in an internal reaction frame. The bar is gripped and pulled at both ends. The bond force is created by restricting the movement of the concrete relative to the bar by means of two calibrated bars. The relative slip is measured by means of four induction-type linear transducers, two being used on each face. The load in the bars is measured with a sensitivity of ± 1 lb and the slip with a sensitivity of $\pm 1.0 \times 10^{-6}$ in.

To observe the bond, crack behaviour, i.e. crack spacing with end growth, the long reinforced concrete tensile specimens are being tested. The length of these specimens are 800 mm, diameter 76 mm. They have a central 16 mm deformed bar. The specimens are gripped at both ends and subjected to a direct pull. All concrete specimens are made using concrete grade 40, max. aggregate size $\frac{3}{4}$ ". The work is divided into three groups, namely, static bond tests, repeated loading tests and fatigue tests. Both kinds of specimens are subjected to the static bond tests. In the case of long specimens the load in the bar is increased in steps and corresponding crack width and crack spacing are recorded. The short specimens are also loaded in steps and the corresponding slips are recorded. During repeated loading bond tests both kinds of specimens are loaded in a similar way. The level of max. pull was established as four different pulls corresponding to different bond deterioration states determined from static bond tests. The pull in the bar will be varied between zero and a constant maximum for 15 to 25 cycles, and the corresponding crack widths and crack spacing will be recorded in every cycle.

Fatigue tests are arranged as tests on a deformed bar in air, tests on effect of cracking and bond and tests simulating flexural cracks. Tests on a deformed bar in air are made with specimens 400 mm and 900 mm in length. Minimum stress in the bar corresponds to 20% of characteristic strength. Maximum stress in the bar was established on four different levels so as to obtain failure within 10^5 to 10^6 cycles.

The effect of cracking and bond is tested using long tensile specimens identical to those used in static bond tests. The steel stress in the bar is varied as above. The crack widths and spacing will be measured at intervals during the fatigue life of the specimens.

Also planned are tests on the influence of simulating flexural cracks on the fatigue life of specimens.

The Cement and Concrete Association is currently carrying out experimental work to clarify what flexural and torsional stiffness should be assumed for support diaphragms in prestressed bridges. They are considering spans in the range of 15 - 29 m, having only support diaphragms. The diaphragms are usually of reinforced concrete but may possibly be prestressed. Unless the bridge is being designed to be continuous for live and, possibly, dead loading, the width of the diaphragms is generally in the range 550 - 700 mm. The research should clarify also whether the diaphragms should be treated as monolithic members or cracked members. This can make a significant difference to the values obtained from analysis for the maximum load effects.

At the Cement and Concrete Association standard bridge beams were designed for spans from 7 m to 36 m. They are described below. The Bridge Division of the Transport and Road Research Laboratory is more involved with steel bridges at the moment. It is carrying out theoretical and experimental research on steel bridges with orthotropic decks. Models of spans are subjected to loadings to failure. Theoretical research is concerned with a study of limit state behaviour.

In the field of bridges the Building Research Station has done interesting research concerned with steel-concrete composite beams. They have tested different kinds of shear connectors for composite beams under static and fatigue loading. An extensive programme of tests was initiated at the Building Research Station shortly after work started on the drafting of Part 2 of the Code CP 117, and further tests were undertaken later at Imperial College.

4. Standardisation in bridge building in the United Kingdom

The first standard bridge beams were introduced in this country in 1961. Their introduction by the Prestressed Concrete Development Group, later incorporated into the Concrete Society, was intended to exploit the economic advantages associated with the repetitive use of formwork and pre-tensioning facilities.

It seems that for spans up to approximately 16 m some form of slab construction offers the greatest economy in this country. The standard inverted T beams, when combined with in-situ concrete, provide reasonable alternative to the in-situ slab. Useful economies are obtained where restrictions exist on the site use of falsework, because of the passage underneath of traffic, the presence of water, or difficult terrain. For greater spans, the dead weight of a slab deck effects considerable increase of bending moment. Thus, for spans about 16 m, the designer has to consider either a multi-cell construction with its efficient transverse distribution properties or a beam-and-slab construction which provides less transverse strength and requires greater construction depth. It seems that in every case of simple bridge shape (in plan as well as in cross-section) using precast elements is advantageous.

Some typical examples of precast girders for bridges are presented below. Some of the standard beams were designed at the Cement and Concrete Association.

Inverted T beams for spans from 7 to 16 m are produced in two standard types. Both types have the same top and bottom flange shapes and the same web thickness, but the depth of web differs. The smaller section is used for spans between 7 and 11m and the larger section for spans between 11 and 16 m. The beams are intended to be placed side by side. After the transverse reinforcement has been positioned through the standard holes, in-situ concrete is placed between and over the units to form a slab deck. A minimum thickness of 75 mm of concrete is placed over the beams. The width of the beams is 495 mm. Holes are provided at 610 mm centres longitudinally to accommodate transverse reinforcement equivalent to $1060 \text{ mm}^2/\text{m}$ length.

Box section beams for spans from 12 to 36 m are also provided in two standard types. For the span range from 12 to 26 m they are produced as pre-tensioned by a specialist precasting manufacturer. For the span range from 26 to 36 m they are pre-cast in segments for subsequent post-tensioning on site. Where site precasting facilities are available, the beams would be cast complete and post-tensioned. The beams are placed side by side at 1m centres and the space between the beams is filled with in-situ concrete. The beams are designed to carry their self-weight together with the surfacing and live load as derived by analysis of structure. Transverse pre-stress will normally be required to ensure the optimum distribution properties in the deck. Transverse prestressing tendons are placed into transverse holes which are provided. The soffit and side forms are common to all beams.

'I' section beams for spans from 12 to 36 m can be considered in two convenient and separate ranges. The first covers spans from 12 to 26 m and the second from 26 to 36 m. It is intended that the beams should normally act with an in-situ top slab and transverse diaphragms. The beams are designed to carry their self-weight and that of the in-situ top slab and diaphragms. The resulting composite section is intended to carry the surfacing and live load.

As the result of co-operation between the Ministry of Transport and the Cement and Concrete Association, standard M beams have been produced for effective spans from 15 to 29 m. The beams have been designed as precast pre-tensioned units for use in composite voided slab (pseudo-box) and contiguous inverted T-beam and slab (T-beam) construction. In general the beams require the use of deflected or debonded tendons for the longer spans. They may be either straight or deflected for the shorter spans. The range of standard M beams has ten sections with different dimensions. The beams are intended to be laid at 1 m centres. A doubly reinforced top slab normally 160 mm thick is cast on permanent formwork.

The U beam has been developed by Dow-Mec Concrete Ltd. The design concept was to combine the torsional properties of the box beams with the simplified construction of the tee beam form. It is intended that the beams are placed at 2 m centres together with 160 mm thick reinforced in-situ slab cast on permanent shuttering. However, if headroom or layout requirements dictate, the beams can be placed at varying centres. In-situ reinforced diaphragms, generally 600 mm thick are made at the ends of the beams for torsional restraint at the supports. The U beams are produced for the span range from 15 to 36 m.

5. Production of precast members

Almost all precast beams for bridges are produced as pre-tensioned. Only segmental girders and for other specific conditions are precast members post-tensioned. One of the biggest firms producing precast members for bridges in this country is Dow Mec Concrete Ltd. All standard beams are produced "as cast" from standard continuous steel moulds on pretensioning beds, generally

72 m long. Economy is attained by the maximum turnaround from each bed. After casting all beams are cured by steam. Moulds and details are standardised. For example the U beam is designed so that a full range of beams can be produced from one mould, having the same pallet width as the M and box beams. In the case of modification to the standard sections, contractors are charged additionally. The cost of modification has been investigated by the Cement and Concrete Association, e.g. non-standard spacing of transverse holes or non-standard size of transverse holes cost 10% more, skew ends 5%, blocking out ends 20% in comparison to the cost of standard elements and so on. Two kinds of seven-wire strand, "Stabilised" or "Dyform", are used for the prestressing of bridge beams. The first strand has 12.7 mm diameter and characteristic strength 167 kN (stabilised) or 213 kN (Dyform). The second strand has 15.2 mm diameter and characteristic strength 230 kN (stabilised) or 295 kN (Dyform). Allowable relaxation loss of 0.7 characteristic strength for all strands is 2.0%.

The smaller span beams are generally produced with fully bonded strands. The structural efficiency of the beams can be increased by debonding the last few metres of some of the strands. This is achieved by covering the strands over the calculated distances with plastic tubing. Another method used is to deflect some of the strand at pre-determined points along the length of the beam.

A trend is observed towards using straight tendons, possibly debonded if required. It allows for easier application of universal casting bed and universal prestressing equipment.

6. Precast bridges on motorways

One of the most typical examples of precast bridges on motorways is the Western Avenue Extension which is elevated road of near motorway standards in West London. Section 5 of that construction was designed as continuous spans of 62.08 m each.

The bridge has two carriageways 12.5 m width each. In cross-section it was designed as multi-cellular concrete girders with long edge cantilevers. The spans were constructed using segments (one in cross-section) approximately 2.3 m long (parallel to the bridge axis). Segments weighing up to 135 tons each were put together using special equipment. The in-situ concrete points were nominally 100 mm wide. After erection of units spans were post-tensioned. The precast segments are trapezoidal in plan to conform to the horizontal alignment of the deck. The single precast segments were designed as prestressed in the transverse direction to the bridge axis.

The longitudinal prestressing used is the PSC Multistrand system with tendons composed of 12, eventually 15 mm diameter strand. The cables were jacked from both ends to 80% UTS (2177 kN/tendon). Total losses were assumed as 15% of the prestressing force. The segmental construction seems to be economical in this country if the total area of the bridge in plan is not less than 10000 m^2 .

7. In-situ concrete bridges

A great number of concrete bridges being constructed are made of in-situ concrete. This method has been used especially on motorways and where construction of a bridge seemed to be more complex.

In-situ concrete bridges are made by the use of modern equipment to allow the mechanisation of the most important processes. The conventional method of placing concrete has been replaced by pumping concrete which seems to be easier, quicker and therefore cheaper. Mechanically driven pumps are the simplest types, but they are relatively heavy with large-diameter, cumbersome pipes and are best suited for placing large volumes of concrete over long distances. The majority of pumps in use are twin-cylinder, hydraulically driven. They are lighter than mechanically powered pumps and can be lorry-mounted. In conjunction with small-bore pipelines (75 or 100 mm) they have been developed into highly mobile units. Using 100 mm pipeline, concrete has been pumped vertically up to 85 m and outputs of up to $100 \text{ m}^3/\text{hr}$ are claimed.

Post-tensioning techniques and equipment are also being constantly developed. As prestressing tendons are used low relaxation wire and strand in sizes up to 18 mm diameter, in which the relaxation loss is 2% or less, after 1000 hours at 20°C , from an initial load of 70% of the material breaking strength. Wire and strand are now available coated with PVC or polypropylene. The strand may be greased, if required, before applications of the plastics and the general dimensions of the covering fall into two categories: thick close fitting sleeve - where the primary purpose is protection against corrosion and thinner loose sleeve - usually polypropylene or polyethylene, for covering greased strands to be used as non-bonded tendons. Loose sheathed strand is widely used in North America for flat slab construction and there is at least one application as stressed stirrups in bridges. In U.K. the major application appears to have been in external cables, passing around deflectors.

The trend is towards larger systems, and cables of 4000 kN are used fairly regularly in bridges. Even larger cables, up to about 10,000 kN are available, although at present their use has been restricted largely to nuclear pressure vessels.

Jacks for cables are themselves of considerable size and normally have to be handled with cranes e.g. the jack for stressing 19/15.2 mm Dyform tendons to about 4400 kN (jack capacity 7000kN) weighs 800 kg. As many uses as possible are obtained using timber or steel formwork.

Timber moulds are used a lot of times, up to 10 uses, and for steel many more uses are possible. It is possible thanks to release agents which are applied. It avoids scaling or scabbing of the concrete when the formwork is removed. Quite a large number of release agents are available.

8. Conclusions

The knowledge and experience which I have gained during my study in the United Kingdom will allow me, I hope, to introduce in Poland some innovations into research work and bridge building practice as well.

Especially important is research on prestressed concrete bridge girders under repeated and fatigue loading. Very important is experimental work to clarify how to support diaphragms and slab influence on structural behaviour of a precast bridge.

The technology of producing precast members developed by Dow-Mec Concrete Ltd., is very interesting. Applications of straight tendons even for large precasts, e. g. box-girders, allows us to use more universal and cheaper casting beds. Thanks to that production of bridge beams could be more flexible.

Also plastic coated prestressing strand seems to be very useful, especially for transverse prestressing of bridges or for temporary construction.

Acknowledgements

I would like to express my gratitude and thanks to:

Technical Assistance Office of United Nations for awarding me the U.N. Fellowship in the United Kingdom;

The Polish Authorities for the arrangement of my study;

The British Council for the arrangement of my study and stay in the United Kingdom;

The Head of the Concrete Section of the Civil Engineering Department of Imperial College of Science and Technology, Professor A. J. Harris, for establishment of the programme of study;

and all persons who have helped me during my stay in this country.

London, 10th July 1974.

A handwritten signature in blue ink, appearing to be 'P. R. S.', with a long, sweeping horizontal line extending to the right.

NATIONS UNIES

COMMISSION ÉCONOMIQUE
POUR L'EUROPE

ОБЪЕДИНЕННЫЕ НАЦИИ

ЭКОНОМИЧЕСКАЯ КОМИССИЯ
ДЛЯ ЕВРОПЫ

UNITED NATIONS

ECONOMIC COMMISSION
FOR EUROPE

Mrs. M.J. Shonkletovich
Training and Fellowship Programme Section,
Office of Technical Co-operation, New York



RECORDS CONTROL

JAN 7 1975

TB 323/1 POLA

*With the compliments
of the Technical Assistance Office
of the Economic Commission for Europe*

29 July 1974

TECHNICAL ASSISTANCE OFFICE
Economic Commission for Europe
UNITED NATIONS

Date of award:

29.11.73 to 1 June 1974

Name and home country:

Mr. A. SLUPCZYNSKI (POLAND)

Field of study:

Computer systems applied to railway operations

Country (ies) of study:

United Kingdom

Aleksander Słupczyński
UN Fellow



FINAL REPORT
on studies in the United Kingdom
29.11.1973 - 1.06.1974

I was graduated in 1970 from the Warsaw Technical University, Electronics Faculty. In the same year I joined Polish State Railways and, after yearly practise covering the most important aspects of railways activity, started working in the Polish Railways Research Institute.

The main task of my institution is designing and implementation of new advanced techniques for railway operations. I have been working for almost 3 years as an analyst and designer of computer systems in our Institute's Data Processing Department. Recently I took part in designing and successful implementing of management information system for a big marshalling yard.

Railways in Poland are the basic and most important mean of transport with tendency to further growth. The existing methods of planning and management, based on manual data collection and processing, can prove in the near future to be insufficient to cope with rapidly increasing traffic. This situation implies the necessity of introducing a computerized real-time freight control and management information system for railways. The provision of accurate and timely information will make possible better utilisation and distribution of freight rolling stock and enable more effective short-term planning at each level of railway operations management.

Designing and implementing of such system, however, is a very difficult task with a great deal of both technical and organisational problems to solve. As the data processing business on Polish Railways at present time confines itself to the batch processing mode it is necessary to get familiarized with experience of other European railways, more advanced in solving similar problems. This led my Government to nominate me for a United Nations Fellowship.

The programme of my half year studies in England consisted of two parts. I have spent 20 weeks with British Rail TOPS Project Team and during remaining 6 weeks attended ICL courses concerning real-time systems. The latter were -

- Management Information Systems,
- Real Time Systems,
- Advanced Real Time,
- Advanced Data Organisation,
- 1900 Driver Programming,
- 1900 Communication Programming,
- 1900 VDU Programming.

My practise with British Rail covered almost all aspects of the Total Operations Processing System which is now being implemented. I spent periods of time varying from 3 days to 3 weeks with following Project sections -

- Planning Section,
- Project Control,
- TOPS On-line Control,
- Computer Operations,

- Systems Control,
- Systems Programming Group,
- Application Programming Group,
- Terminal Development,
- Telecommunications,
- Implementation Teams.

More effective distribution and higher level of resource utilisation are the obvious reasons for introducing computerized freight control system at a certain level of railway development. British Railways achieved the fast provision of a data base for a comprehensive management information system having adapted the existing, tried and tested Southern Pacific Railways TOPS. Such approach made possible to shorten the time needed for system definition, integration and testing as well as to reduced both risk of failure and time of the implementation. On the other hand the successful introduction of TOPS on both SP and BR railways proves its potential usability for any railway company.

The main feature of TOPS is continuous updating of the data base with information concerning basic events of railway operation. It enables having the precise image of real situation in the computer files.

The true responsibility for the reporting of location and state of all railway vehicles is established by means of Responsibility Areas with TOPS Offices, connected on-line to the computer, as their nerve-centres. The latter are not only a part of reporting system, but constitute the information source for local planning and management purposes.

Field procedures has been designed to ensure both great accuracy and simplicity of reports by using punch cards as turn-round document. Computer checking on the sequence of events, clear error comments, easy to use pigeon-hole card filling system and TOPS On-line Control assistance make TOPS Office clerks job relatively easy in assumption they are in possession of exhaustive information concerning events taking place within their areas.

The input reports to the computer after passing relevant logical checks update a series of dynamic files reflecting the state of whole freight system. Access to this information by means of enquiries to the on-line data base as well as off-line statistics provide quite new, invaluable material for operations management at all levels.

At the level of marshalling yard TOPS provides yard supervisors with summarised traffic information for work planning purposes. The up-to-date detailed state of yard is always available as well as precise information of how traffic will be developing during next hours. TOPS information sources enable considerable reduction of work involved in numbertaking and train preparation. A printed consist list received prior to the arrival covers full details of all wagons on the train. By means of tagging system this can comprise also indication concerning yard siding the wagon should be shunted into. Precise calculation of loads and length of outgoing trains is possible

by listing of wagon cards by length, weight and brake force for given siding. In this situation time spent in processing wagons through the yard can be reduced to a minimum.

With TOPS the necessity of collecting and preparing data for control from higher levels of management does not exist any more. Availability of TOPS reports at Territory level enables more advance planning, better allocation of resources and current monitoring of freight operations.

Under TOPS system of empty wagons distribution can be improved to a great extent. Information available to wagon distributors incorporates all wagons in the fleet. It makes possible the tight control from the central place over empty movement and its treatment in the same manner as loaded. By means of TOPS procedures and disciplines proper destination can be automatically applied to an empty wagon when it is to be released for movement. When necessary, complicated distribution instructions can be change easily and quickly. The accurate and timely reports to wagon distributors give them efficiency measure of their efforts.

From the viewpoint of railway customers TOPS gives information of their loaded traffic whereabouts, empty wagons they require, predicts time of arrivals but also can keep control over the use of wagons.

The precise records of past activity of each train, wagon and locomotive are processed to give the comprehensive information concerning vehicles utilisation

and maintenance, traffic flows, stations activity by desired periods of time.

On the computer side the central processing units enable high level of reliability and fast response to messages from terminal devices. Constant availability, high message rate and data base integrity are provided by the TOPS system programs. The three partition system including communication control, message edit and message processing comprises a number of significant features as -

- no message loss by means of checkpoint / restart capability,
- supporting a variety of both low and medium speed terminal devices,
- restrictions in system and file access to authorized users,
- validation of all input messages,
- economical storage of large volumes of on-line data,
- efficient handling of file requests for a great number of files,
- record checkpoint and capability of reconstructing on-line files.

Application programming is greatly simplified by making use of several service programs and macros. Programming standards and data specification system provide uniformity in implementation and easiness of changes. There are also sophisticated testing, diagnostic and system control facilities incorporated into the system.

There is a number of notable features within a complex communication system connecting computer with field terminals and also extended facilities of remote control, testing and monitoring of telecommunication lines.

The full use of TOPS can be made after entire cut-over. The fast and successful introducing of the system depends to a great extent upon performance of training and implementation teams. Especially the latter have very responsible task in establishment of unfailing reporting methods and cooperation granting the proper information flow within responsibility areas.

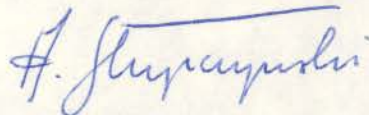
Invaluable help in process of operators training gives TOPS training mode facility enabling the use of real procedures without affecting the rest of system.

All TOPS features mentioned above compose the powerful, reliable and expansible system which can successfully cope with further increasing needs of whole railway system. It inevitably gives substantial economical benefits which will be brought to light after full cut-over and establishing of TOPS users' procedures.

It must be emphasised that apart from technical factors success of the enterprise of this kind is strongly based upon the involvement of high levels of management and advanced methods of project organisation.

My practise with TOPS Project has given me a great deal of real knowledge about all aspects of this advanced real-time system and its application to railways operation. This experience as well as the theoretical background gained on ICL courses will be of a great value in designing of freight control system for Polish Railways.

I would like to express at this place my gratitude to all organisations involved in accomplishment of my practise for their considerable assistance.



/Aleksander Słupczyński/

Warsaw, June 1974

NATIONS UNIES
COMMISSION ÉCONOMIQUE
POUR L'EUROPE

ОБЪЕДИНЕННЫЕ НАЦИИ
ЭКОНОМИЧЕСКАЯ КОМИССИЯ
ДЛЯ ЕВРОПЫ

UNITED NATIONS
ECONOMIC COMMISSION
FOR EUROPE

~~Mrs. M.J. Shoukletovich~~
Training and Fellowship Programme Section,
Office of Technical Co-operation, New York



N/R

TE Country file
RECORDS CONTROL
NOV 13 1974

TE 323/1 POLA

*With the compliments
of the Technical Assistance Office
of the Economic Commission for Europe*

29 July 1974

TECHNICAL ASSISTANCE OFFICE
Economic Commission for Europe
UNITED NATIONS

Date of award:

8.1.74 to 6.7.74

Name and home country:

Mr. Andrezej KMIEC (Poland)

Field of study:

Relay protection of EHV power systems
with transistor logic circuit and
Country (ies) of study: integrated circuits

the United Kingdom

The University of Manchester Institute of Science and Technology

Electrical Engineering and Electronics.

Static Relay Protection of E.H.V. Power Systems.

Final report

by Andrzej Kmiec

Holder of United Nations
Fellowship

June 1974.

CONTENTS

1. Introduction
2. Application of Transistors and Integrated Circuits to Power System Protection.
 - 2.1. Advantages of static designs.
 - 2.2. Basic practical circuits in general.
 - 2.3. Basic principles of A. Reyrolle's/RPGI/ static relay design.
3. Transient Overvoltages in Secondary Circuits.
 - 3.1. Origin and cases of surges (measurement methods and results.)
 - 3.2. Effects of surges on protective relays.
 - 3.3. Means against surges used in static relays.
 - 3.4. Insulation and impulse tests of static relays.
4. New Trend in Solution of Super High Speed Power System Protection.
 - 4.1. Application of digital technique for protection of power systems.
 - 4.2. Modern design of E.H.V. two-cycle circuit-breakers.
5. Conclusions.
6. Acknowledgements.

1. Introduction.

I graduated at the Technical University of Warsaw, Electrical Engineering Department in 1959 as a Master of Science in Relay Protection Engineering.

Since 1958 I have been working with the Institute of Power in Warsaw, firstly as a junior research assistant and then as a senior assistant.

In 1971, I gained a Ph.D. degree and than I was appointed head of Transient Phenomena Section of High Voltages Laboratory.

During my latest work in the Institute, I have been mainly dealing with the following problems:

- a). Switching surges in power systems (field and transient network analyser measurements and investigations).
- b). Transient network analyser modelling measurement and control technique development.
- c). Research of EHV transmission lines effect on telecommunication circuits.
- d). Design of control equipment with solid state devices.

Most recently the author's work has been concerned with research on transient overvoltages in secondary circuits of EHV substations.

Development of the Polish Power System requires the new protective technique to be introduced. Modern statis relays with improved performance characteristics and shorter operating times

have been taken into account as well as new designs of faster circuit-breakers have been considered, to be applied in power systems.

For reliability of static protection, three groups of problems are particularly important:

- a). Levels of overvoltages and surges in secondary circuits and their possible effects on protective static relays.
- b). The arrangement of static circuits to avoid the effect of surges.
- c). The appropriate voltage tests of static protection.

The problems presented, and its prospects for the Polish Power System, require intensive research work on these subjects, and collaboration with the countries which have the best experience in this field. England is one of the leaders in static system protection field, as well as in manufacturing of fast operating E.H.V. circuit-breakers.

In the United Kingdom, the author was granted a six months science fellowship. During this time, he joined the following Divisions of A. Reyrolle & Co. at Hebburn:

- a). Relay Protective Gear and Instrument Division
(R.P.G.I.) - three months.
- b). Switchgear Division (E.H.M.V.) - five weeks.

He had the opportunity to learn new techniques in the design, construction, manufacturing and routine testing procedure of static protective relay equipments. He also took part in the

type tests of a new design distance protection and has acquired the technique of Protective Gear Test Bench. Apart from the last the author has been acquainted with the physical body of high and extra high voltage circuit-breakers, and took part in the development of circuit-breaker tests at Reyrolle Research Station. He has been familiarized with the measurement circuits and the instruments used in Reyrolle Short Circuit Laboratory.

Short Circuit Laboratory.

In addition to the above the author has acquired the Reyrolle Transient Network Analyser technique and methods of representation various actual system components in model scale. After his training with A. Reyrolle, the author joined the Electrical Engineering and Electronics Department of the University of Manchester, Institute of Science and Technology. For six weeks, he has been studying the problems concerning the measurement methods, and equipments used during the field measurements of the transient phenomena in secondary circuits.

During this time, he visited the University of Salford and had the opportunity to familiarize himself with the D.C. power transmission simulator.

The overall program of the author's study in the United Kingdom has been fulfilled completely.

This report contains briefly the author's observations during his training. More detailed report will be prepared later for Polish's Authority.

2. Application of Transistors and Integrated Circuits to Power System Protection.

2.1. Advantages of static designs.

2.1.1. Performance improvement.

Over the last ten years, transistorised relays have been shown to be practical alternatives to conventional electromechanical designs. Furthermore, the transistor technique can afford greater freedom in design for specific laws of operation and characteristics. This has no counterpart in the electromechanical relays, where the basic characteristics are prescribed by the behaviour of the element itself.

The transistorised relays may be designed to have a wider range of different characteristics with improved performance, mainly in terms of measuring accuracy and speed. This includes a close approximation to an electromechanical unit, as well as characteristics not normally obtainable by conventional means.

For this reason mainly, static relays have become more suitable for modern power system protection. Further progress in static relay design field is achieved.

2.1.2. Reliability.

High reliability is of course essential for all protective equipments. The inherent reliability of modern semiconductors and associated passive components is sufficiently high to guarantee their application to protective devices.

A professional grade of these components applied in the right environment can be assessed as having a life of at least twenty years /the lifetime of most protective equipments./

There are two aspects on the reliability of static circuits:

- a). the semiconductor failures which can be resulted by transient overvoltage. This involves a great number of rules of relay design and requires careful consideration.
- b). the ability of the relay to function correctly even in the presence of transient input signals. This is particularly important in the case of high speed system protection.

Thus, from the reliability point of view, the careful choice of components and circuit assessment, as well as additional proper precautions, are necessary.

2.1.3. Cost.

The rapid development of technology in the manufacture of semiconductors and passive components has resulted in extremely reliable and low cost components. Nowadays, the transistorised relays have become cheaper than their electromechanical counterparts, and a further decrease in cost will be achieved in the near future.

2.1.4. Size.

The static technique permits the size of the relay to be reduced. The smaller size is resulted not only by the use of small semiconductors and passive components, in measuring circuits, but also due to the use of static circuits, instead of various mixing transformers.

2.2. Basic practical circuits in general.

2.2.1. Interface /input-output/ circuits.

In order to allow the signal levels to become compatible

with static circuitry, as well as to protect these latter from surges in secondary wirings, the interface circuits are provided. Quite often the interface allows adjustment of some parameters to cater for the system operating conditions.

The most common of all input interface circuits is an isolating transformer, which may be a current or voltage type, and may have a primary, or secondary with multiple taps to facilitate a change in setting of the relay. By careful design of its parameters, the isolating transformers can be made to operate in a linear fashion over a large range of input signals.

Output interface circuits usually are formed by the high speed relays, normally the need relays with the catered insulation level between contacts and coils.

Both input/output interface circuit insulations form a high voltage barrier between the external circuits and the internal static circuits.

2.2.2. Starter circuits.

Starter circuits are used to detect the presence of a fault on the system and to initiate action, usually to switch on direct current power supply to the static measuring and tripping circuits. These starter circuits may be formed by overcurrent/undervoltage circuits as well as by impedance measurement starting circuits. The latter method is associated with switched type distance protection schemes. Both overcurrent and undervoltage starters include the bridge rectifiers and associated transistorised circuits with output formed by reed relays. Proper design of circuits results in a satisfactory operating and reset characteristics

/the drop-off to pick-up ratio/ to be obtained.

The basic performance of impedance starting elements is based on the phase, or amplitude comparison of current and voltage input signals; However, the other methods (pulses or sampled techniques) are also taken into account.

2.2.3. Definite time lag circuit.

In the time lag element, modified miller circuit is used. The principle of operation is based upon the exponential charge of a resistor-capacitor combination. The time delay is initiated by the closure of input switch which connects a d.c. voltage supply to the circuit. The capacitor voltage rises to a reference potential of level detector, which via the output amplifier causes the output relay to switch on. The resistors used in the circuit are metal oxide type and were chosen, because of their high reliability and long term stability. The timing capacitor is the most important component, since the overall performance depends directly on its quality (mainly), insulation resistance, dielectric absorption, and change of capacitance with temperature. Capacitors with dielectrics of polycarbonate or polyethylene terephthalate have been provided to give excellent results.

2.2.4. Measuring Elements.

a). Single input measuring elements. Input signal is compared with fixed electrical signal and output impulse occurring usually when average or r.m.s. value exceeds this fixed value. To do this with high reliability and speed, one or more basic processes such as filtering, rectification and smoothing must be done. In approaching the design of a measuring element,

having high speed and reliability, the following aspects are taken into account:-

- The accuracy in the presence of direct current transients in current waveforms.
- The pulsing time of the device should be the same as its operating time.
- The operating time ideally should be the same as the overall time.
- The reset ratio - ideally, should approach unity.
- The reset time should be of the order of five times the fastest operating time.

A transistorised relay, in which the individual characteristics may be controlled, shows the way in which performance may be related to the obtaining of required accuracy and speed¹₂

Minimum operating times of about 10 - 15 ms are possible with reasonable accuracy of measurement.

b). Two input measuring elements.

Two input measuring elements are used in distance protection. As this protection is used on many transmission circuits, minimum operating times may become essential. The various static two input measuring elements technique can be broadly categorised as:-

- (a) Those which are based on the continuous assessment of input quantities and which retain a controlled degree of inertia in the form of integrations. This technique is usually referred to a block average comparison.
- (b) Those which are based on an instantaneous or pulse principle, where the decision to trip can be taken from a single measurement in a fraction of a millisecond.

The steady state performance of both types of comparators is identical. However, their dynamic performance may be quite different. Comparators operating on the principles given in Ib) are usually faster in operation than the block average comparators, but they are more susceptible to system transients and other spurious signals, by virtue of their near instantaneous operation.

2.2.5. Power supplies.

The reliable d.c. power supply is essential for all kinds of static protection systems.

There is in practice, to power the static equipment from built-in battery source, usually of the nickel-cadmium sealed cell type with a battery charge electronic control circuit. Alternative arrangements using d.c./d.c. converter are also provided for powering the equipment from the trip battery.

2.3. Basic principles of A. Reyrolle /R.P.G.I./ static relay design.

2.3.1. Definite time lag relay /types TCO and TDS/.

Relays are fitted with static time lag circuit and self-reset electromechanical repeat-contactor in order to provide the high contact ratings necessary in control and tripping circuits. Relays may be supplied with one of several time-ranges rising from (0.01 - 0.9) to (2.0 - 60.0) seconds.

The principle of operation is described at 2.2.3.

2.3.2. Overcurrent Relays /type TEE/.

Comprises input transformers, surge diverters, current-setting links and potentiometers. The latter presents an output-voltage to a level detector which, upon operation, energises

a high-speed, dry-need element and hence an attracted-armature repeat-contactor.

2.3.3. Under/overvoltage Relays /types TEB1 and TEB2/.

The relays consist of a tapped input transformer with plug-bridge settings, a level detector and an attracted-armature repeat contactor. A single-phase and three-phase version are available.

2.3.4. Inverse Definite Minimum Time Lag Relay (type IDMTLR).

The relay consists of four basic blocks: input and starting circuits as previously described, a non-linear shaping circuit, a high gain phase reversing amplifier with capacitive feedback and a level detector feeding an output amplifier. The non-linear shaping network produces output current which is certain non-linear function of the input voltage comes from input starting circuit. This current is fed into Miller type high gain amplifier with capacitive feedback.

This Miller integrator produces a voltage ramp with respect to time of constant current input. The slope of the ramp depends on the magnitude of the input current. When the voltage from the Miller integrator reaches a prescribed values, the level detector operates and energises the output circuit via output amplifier. In this way, as the level of the current into the Miller integrator is increased, the operating time of the circuit is reduced. The current fed into Miller integrator depends on the primary current of the starting circuit and form of the shaping network. This enables almost any time-current characteristics to be realised by producing the correct shaping network.

A time multiplying feature is incorporated by dividing the voltage output from the Miller integrator with a resistance divider circuit.

2.3.5. Distance protection /types THS & THR/.

Static distance protection design - type THS and THR - is based on the continuous assessment of input quantities, usually referred to a block average comparison.

Comparison of the system fault currents and voltages for impedance measurement is by means of a two input phase-angle comparator circuit which produce output signals when the phase-angle between two input signals lies within 90° . Depending on the quantities chosen, Mho and Offset Mho characteristics are obtained.

Practical realisation of transistorised distance relay requires the following elements to be assessed;

- a). Interface input circuits described in 2.2.1.
- b). Mixing circuits usually formed by summing amplifier with high loop gain and output limits in the form of a rectangular wave. The resultant amplitude distortion however is of little significance, since the amplifier feeds a phase comparator.
- c). Impedance measurement element formed by means of a two-input phase-angle comparator circuit, which operates as coincidence circuit and gives output pulses when the input quantities have the same polarity.

d). Integrator and Level Detector.

The integrator ultimately determines the dynamic performance of the comparator in terms of speed of operation, and freedom from transient overreach, and as such requires more detailed description. Under quiescent condition the integrator output voltage is effectively at zero potential. During a period of polarity coincidence of the input signals the output voltage of integrator increases linearly at a rate determined by the net input current and the feedback capacitor. During non-coincidence period the integrator output falls linearly at a rate determined by the feedback capacitor and resistor. The ratio of the "rate of rise" to the "rate of fall" defines the critical pulse width and hence the phase angle criterion of the relay. The minimum integrator response time must be related to the longest pulse obtainable from the coincidence circuit under conditions of maximum d.c. offset transient.

This would occur for the limiting condition where one of the inputs has only one polarity producing a coincidence pulse of exactly half a cycle. Transient overreach is avoided, by ensuring that this abnormal pulse does not actuate the level detector. This consideration therefore sets a limit on the minimum response time of the comparator. Thus having determined the operate level of the detector together with the integrator rates of rise and fall the dynamic performance of the relay is completely predictable over its whole working range. Optimum performance is achieved with a setting of $2/3$ integrator excursion limit and a reset level of $1/3$.

3. Transient Overvoltages in Secondary Circuits.

Surges which may have been occurring in secondary circuits with electromagnetic relays for many years without any undesirable effects, can produce adverse results when associated with transistor circuits. The latter are made much more sensitive and consequently are able to operate at very much lower voltage levels. Also, the amount of surge energy required to cause damage or maloperation of transistor circuits is quite small.

For this reason, a better understanding of the mechanism and levels of the surges in secondary wiring are particularly important.

3.1. The origin and causes of surges.

One major of surges is associated with switching functions either in the main circuits and auxiliary circuits or even with protective relay itself. The switching may be in many forms and may result in a sudden change of circuits quantities. This can be initiated by closing a switch in the auxiliary circuit, operating a line circuit-breaker or isolator and may also be initiated by semiconductors in control or relay circuits. Another cause of surges may be the occurrence of fault on the system due to the lighting strikes, mechanical interference, or insulation breakdown. The transmission of surges of protective circuits can take place through conductors, capacitive or/and inductive coupling, earth path, through space or any combination of these factors. The magnitude of the surges reaching the relay terminals depends, to some extent on the attenuation of the multi-core cables or pilots

used in secondary circuits.

3.1.1. Surges in secondary wiring associated with protection circuits.

The investigations, include both long term statistical measurements and specific site measurements, were carried out at the 275 kV and 400 kV substations. Surges were measured using the surge monitors designed to record the occurrence of voltages exceeding four preset levels. The response time most of surge monitors was 0.2 μ s. The monitors were connected to the secondary windings of the capacitor voltage transformers and current transformers, as well as to carrier line coupling capacitors and to station battery circuits. The longest statistical measurements were carrying out during 19th month. The greatest overvoltage measured exceeded 3 kV five times. No surges were recorded at 5 kV level. During the controlled tests, which were carried out separately at certain chosen sites /switching operations of circuit breakers and isolators/, the highest voltage recorded at the relay terminals was less than 250 volts. These values, however, were obtained at the presence of steel wire armouring of the multicore cables earthed at both ends, as it is in normal practice in England. If only one end of the armouring is earthed or if it is not earthed at all, the magnitude of the overvoltages increases.

The magnitudes of 10 - 15 kV were observed, between the relay room earth and the earth point of C.V.T. This shows that the cabling arrangements to the relay room can make an appreciable difference to the voltages appearing at the relay terminals. The

frequencies of surges recorded were between 700 - 100 kHz.

The highest overvoltage observed on D.C. battery circuits was around 300 volts.

Of great importance are surges due to the capacitive energy stored by the wiring connected with tripping relays. The capacitance of negative wiring to earth is commonly around 10 μF and has been known to reach 60 μF . In the cause of earth fault condition at the point of tripping relay, it may operate due to discharge current above mentioned capacitance. The effect of this type of surge is expected to be minimised by the proper design of the tripping relay.

3.1.2. Surges associated with the relay circuit.

These types of surges may occur due to the following reasons;

- a). closing of trip circuits by contacts or thyristors and discharge of circuit capacitors which can be transmitted to sensitive circuits through inductive coupling,
- b). interruption to the current in inductive circuits, can generate a back e.m.f. of high magnitude,
- c). reversal of the D.C. supply may result damage of circuits,
- d). saturation of non-linear elements can produce overvoltage and high current surges,
- e). unwanted coupling or feedback loops may cause high frequency oscillations.

These types of surges are under the control of the relay designed and may be eliminated if proper principle design and

sufficient precautions are used.

3.2. Effects of surges on protective relays.

3.2.1. Maloperation.

The more sensitive circuit is made, the more prone it will become to interference. For this reason, the designer should find the optimal solution between sensitivity and stability of performance under interference conditions. The most prone to maloperation are pulse operated circuits and these arranged in form of high speed voltage level detectors. Any short duration interference surge may cause non desirable operation of the circuit. The reed relays and particularly thyristors used as tripping relays are faster and much more sensitive counterparts to the conventional type tripping relay. Thus they are prone to maloperation due to discharge of the wiring battery capacitance.

Under certain conditions, induced voltages of power frequency in secondary circuits may affect the protective relay characteristic.

3.2.2. Damage of components.

Since of small size and small thermal capacity, semiconductor components are particularly prone to damage due to surges and high frequency oscillations. In the case of slight damage only the transistor will exhibit abnormally high leakage and low gain. More extensive damage usually results in a short or open circuit. Thus, transistors used in static relay circuits must be protected against overvoltage and current surges.

3.3. Means against surges used in static relays circuits.

The following protective means have been provided in order

to ensure surge proof of static devices used in system protection:

- a). sheilding cables with effective screening ratio,
- b). proper manners of earthing,
- c). interface input transformers with single or double screens,
- d). output elements with high voltage barrier between internal and external circuits,
- e). protective components like for instance, zener diodes, nonlinear resistors,
- f). isolated transformers in supply voltage circuits /dc/dc converter/,
- g). correct design methods and applying the most transient free circuits,
- h). input RC or LC filters,
- i). general arrangements and wiring precautions.

Above precautions except a) and b) are used in the A. Reyrolle relay designs. As example of surge proof design is distance protection based on a block type phase comparator. Any surge voltage which may get into the comparator are limited in amplitude to the height of the block. Since the time duration of the surge is usually very small, any error caused by such surge is negligible.

3.4. Insulation and Impulse tests of static relays.

Required standard for surge immunity in use in the United Kingdom is defined in BEAMA publication No. 219. These requirements are based on proposal International Electrotechnical Commission/

IEC Committee No. 41, Sub-Committee No. 41B:- Measuring Relays - Working Group 1, August, 1972/ for impulse testing of static relays.

The proposals of IEC include three levels of test voltage referred to as Class I, Class II, and Class III. It has been assumed that overvoltages does not exceed the highest level of 5 kV. Voltages higher than 5 kV should be reduced at the source of generation to the level of voltage appropriate to the class declared by the manufacturer.

There are two principal groups of voltage tests:

- a). Impulse voltage withstand tests.
- b). High frequency Disturbance tests - longitudinal and transverse modes.

3.4.1. Impulse-Voltage Withstand Tests.

For the withstand test the impulse voltage is an aperiodic transient voltage without appreciable oscillations. Impulse waveform should be the standard 1.2/50 μ s with voltage rise time tolerance $\pm 30\%$ and voltage fall time tolerance $\pm 20\%$. Source impedance - 500 Ω with tolerance $\pm 10\%$. Source energy - 0.5 joules $\pm 10\%$. Standard value of test voltage depends on the class of tested relay. For Class II this value should be 1 kV peak (+ 0, - 10% tolerance) and 5 kV peak (+ 0, - 10% tolerance) for relays of Class III. Relays of Class I do not require Impulse voltage tests.

The standard Impulse generator circuit is recommended by IEC and BEAMA. Such impulse generator is used during insulation tests at R.P.G.I. Division of Reyrolle Co. Ltd.

3.4.2. High Frequency Disturbance Test.

These tests are recommended in order to determine whether a relay will mal-operate when high frequency transients are applied on a fully energised relay.

The standard waveform should be a damped oscillatory wavw with the envelope decaying to 50% of peak value at the end of 3 to 6 cycles. Frequency - 1.0 MHz \pm 10%. Source impedance - 200 Ω \pm 10%. Repetition rate - 400 per second. Duration of test - 2 seconds \pm 10%, - 0.

Standard value of test voltage~~s~~s 1kV (+ 0, - 10% tolerance) for relays of Class II and 5 kV (+ 0, - 10% tolerance) for relays of Class III. Relays of Class I do not require high frequency tests. The test voltage levels are the voltages at the output of the test circuit before the relay is connected to the test circuit terminals. The standard impulse generator circuit for high frequency tests is recommended by IEC and also by BEAMA.

The author of this report had the opportunity to be familiarized with impulse and high frequency test procedures in A. Reyrolle Co. at Hebburn. Detailed information on this matter will be given in additional report.

4. New Trend in Solution of Super High Speed Power System Protection.

The development in transmission systems has resulted in requirements for shorter and shorter protection operating times. The combination of protection and circuit-breaker is a single control loop, and the overall functioning time depends on independent stages within this loop. So, new trends in design

and prospects to set up the minimum overall time will now be discussed separately.

4.1. Application of digital technique for the protection of power systems.

Further development of transistored relays based on block comparison or pulse comparison of measurement principle, will undoubtedly result the timing characteristics to be improved. But limiting values of shortest operating times lies within 5 - 10 ms for single input relays and 10 - 20 ms for two-input relays.

Recently, the use of digital computers, to perform many of electrical power system protective relay functions, has been considered. The instantaneous value of the station voltages and currents may be sampled (for example at a 0.5 ms rate), converted to digital form and stored for computer main-frame use. Computer speed in initiating tripping is a maximum of 4 ms for severe faults and a maximum of 10 ms for moderate or distant faults.

Apart from very good timing characteristics, this method may be also more economical. The cost of computers can be shared with non-protective functions live data acquisition and control.

However, application of computers and sampled data technique, requires the special precautions against interference voltage in the secondary wiring which must be used.

First of all, the station control cabling must be well shielded to minimise both magnetic and capacitive coupling with interference sources.

4.2. Modern design of E.H.V. two-cycle circuit-breakers.

In order to achieve minimum overall times with proper reliability level it is necessary to reduce the operating time of circuit breakers. Improvements in circuit-breaker designs are possible to comply with these requirements.

Modern two-cycle circuit-breakers are actually in service in the most developed countries. Further development in this field is achieved. Particularly, prospects of using SF_6 and vacuum, circuit-breaker interruptors are very attractive. Also the air-blast pressurized circuit-breakers cover heavy duty and high speed requirements. The Reyrolle air-blast circuit-breaker range type OHBR is a very good example of such designs. The modular construction has three main features. First is the high breaking capacity per break which is obtained by use of high pressure air (63 bars).

Second, quiet operation is achieved by the use of integral silencers. Third, high speed of operation due to reducing the mass of moving parts and coupling the main contacts directly to the operating mechanism. The total short-circuit break time is reduced to 2 cycles. The author has had the opportunity to be acquainted with the details of physical body and the results of type tests OHBR circuit-breaker. This information is very interesting in view of the possibility of high speed system protection and also in view of representation of modern circuit breakers in Transient Network Analyzer.

5. Conclusions.

5.1. Application of static relay protection in Polish Power System require first of all to answer on the question what levels of switching surges and transient overvoltages occur in secondary circuit of polish stations and substations. Field measurements should be carrying out to determine how dangerous hazard must be taken into account. In these problems, the author's experience, gained during his study in the United Kingdom will be very useful. Particularly, application measurement methods and technique used in England will accelerate in great extent this research work in Polish environments.

5.2. On the other hand, the static relay itself should comply with impulse and interference voltage requirements to ensure the reliable performance under various service conditions. Similar, as it is in practice in the United Kingdom, it is necessary to provide both of insulation and interference tests static relay protection during type test. The present standard (BEMA publication No. 219) in use in the United Kingdom has been shown good enough to ensure long term static relay service with a reasonable probability of maloperation or damage.

Methods and measurement techniques used in the United Kingdom during insulation and interference tests should be accommodated into Polish conditions. In this matter the authors experience will be particularly useful.

5.3. Application of serious precaution against surges during design and assessing procedure of transistorized relays is essential. Most number of these used in the U.K. will be taken into account in

polish design of static distance protection.

5.4. Much information concerned with testing methods, measurement-circuits and instrument at the short-circuit laboratory of Reyrolle Co. Ltd. will be especially useful in furthering the authors research work upon characteristics of switchgear equipment.

5.5. During his study in the United Kingdom the author had the opportunity to compare modeling techniques used in T.N.A. of Institute of Power with actual knowledge about latest modern design TNA in England and Australia. This will result in a further improvement and development of TNA in the Institute of Power.

To conclude, the whole programme of the authors training in the United Kingdom has been fulfilled. Much experience and interesting technical information will be very useful in further authors activity after returning to Poland.

6. Acknowledgements.

I am grateful to Mr. F. L. Hamilton, Manager of Relay Protective Gear and Instruments Division, and Mr. D. Lichtle, Manager of Engineering Section Extra High Medium Voltage Division for the facilities provided during my study in the fore mentioned Divisions of the A. Reyrolle & Co. Ltd. at Hebburn.

I wish to thank Dr. L. Jackson and Mr. J. Stulle as well as their staff for their supervision, valuable discussions during my three month training with R.P.G.I. Division. I should also like to thank Mr. M. Scott and Mr. W. Ritchie for their help and collaboration in problems concerning my study at the Design &

Research Division of A. Reyrolle.

I would like to express my thanks to Dr. W.D. Humpage for his supervision during my study with the Electrical Engineering and Electronics Department of the University of Manchester Institute of Science and Technology, and to Mr. K. J. Cornick for very interesting discussions about TNA technique.

I am very grateful to the United Nations Technical Assistance Office and the Polish Authorities for the award of the Fellowship in the United Kingdom.

I also wish to take the opportunity to express my thanks to the British Council and particularly Mr. R.S. Kay, the Programme Organiser in London, Mr. D.W. Stancombe the Deputy Area Officer in Newcastle, and Mr. J. Clarke the Fellowship Officer in Manchester for their help and patience in various arrangements during my stay in the United Kingdom.