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Mrs. Shoukletovich

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



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TECHNICAL ASSISTANCE OFFICE
Economic Commission for Europe
UNITED NATIONS

Date of award:

December 1972 - 2 June 1973

Name and home country:

Mr. J. ZAWADZKI, Poland

Field of study: Construction technology of
bituminous pavements for motorways and heavy
traffic roads.

Country (ies) of study:

Italy

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Through:

Istituto Nazionale per l'Incremento
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Piazza Indipendenza, II/B
00185 R O M A - I T A L I A

The Final Report of Study in Italy

The subject of study: Construction Technology of Bituminous
Pavements for Motorways and Heavy
Traffic Roads.

The period of study: from December 5, 1972 to June 5, 1973

Janusz Zawadzki
an engineer of Civil Engineering
the home address:
30 E Walcowniuza Str.
04-921 Warsaw - POLAND

I. Introduction.

In my country I work for Road Research Center at its Department of Bituminous Pavements in Warsaw.

I have worked there for seven years and as far as my department is concerned I have been only engaged to the problems of technology bituminous pavements and asphalt binders. According to needs of my country, the Road Research Center in Warsaw fulfils^{the} three main tasks:

- carrying on research works,
- playing a role as expert in some questionable technical matters, and writting technological instructions,
- organizing special courses for improving the knowledge of technical personel from province laboratoires.

Therefore my activities as a research worker is concerned only with such kind of work like mentioned above.

II. Aim of study.

The construction of new roads and modernization existing network have become the urgent need in my country in connection with the increase of motorization caused by a development of industry and actually existing trend of people toward buing cars.

My institution is facing up to the special important tasks at these new plans. First of all we have to enlarge ^{our} ~~an~~ activity to fulfil the new necessities following the actual work^L technique.

For this reason instructing a technical personnel of my institution in countries with a big experience at the construction of roads, performs a special important role.

It is expected that the information obtained by me in Italy will be helpful in the solution of the problems as follows:

1. The standard and research methods of testing the constituents of bituminous mixtures materials and specification requirements for them.

- a) the ^tests of asphaltic binders,
- b) the ^tests of mineral aggregates.

2. Conditions of component materials selection (Binder and aggregate) which are applied for production of bituminous mixtures and for the variety constructions of bituminous pavements resulting from the intensity of traffic, climate, economic and local conditions.

3. Design methods of bituminous mixtures in relation to their durability, stability, climate conditions, de-

stination and a kind of used materials.

- a) selection of the grading of the aggregate,
- b) determine^{ig} of the optimum asphalt content.

- 4. Production technology of the hot-mix asphaltic concrete (temperature control, maintaining the mix within job-mix formula limits).
- 5. The organization of modern hot-mix plants.
- 6. Technology of the setting bituminous hot mixtures up into pavement bases and surfacing courses (the conditions of spreading and compaction of mixtures).
- 7. Quality control of the production and setting up bituminous mixtures.
- 8. Design of bituminous pavements structures.
- 9. Technologies and construction methods of skid resistant wearing courses.
- 10. Construction of hard shoulders.
- II. Construction of bituminous pavements on road bridges and viaducts.

III. Realization of the Program of Study

I. Institutions and sites visited.

My program of study had been prepared in principle by my supervisor and after when I came into contact with the main institutions it became possible for me to enlarge the number of institutions which were interesting for me.

I have visited the institutions and sites during my staying in Italy as follows:

1) "Autostrade" - Concessioni e Costruzioni

Autostrade S.p.A.

a) the Central Direction in Rome,

b) the Central Laboratory of "Autostrade" company in Piano Romano.

2) SCAI - Società Costruzioni Autostrade Italiane S.p.A.

a) the Central Direction in Milan

b) the Direction of provincial executive office of SCAI in Bologna,

- the Central Laboratory of provincial executive office of SCAI in BOLOGNA,

- the plant in Bagnacavallo and works under construction on the Bologna - Ravenna motorway,

- the plant in Sasso Marconi and works under construction on the Bologna-Florence motorway,

- the works under construction in Campogalliano on the Milan-Bologna motorway.
- 3) ANAS - Azienda Nazionale Autonoma delle Strade
 - a) the General Direction - the Office of Program-
mation and Study in Rome
 - b) Centro Sperimentale Stradale of ANAS in Cesano
 - c) Ufficio Speciale per l'Autostrada Salerno-Reggio
Calabria of ANAS in Cosenza
 - the plant in Castiglione Scalo and works under
construction on the Cosenza-Crotone State Road
n. 107.
 - the main viaducts on the Salerno-Reggio Cal-
abria motorway.
 - d) Ufficio Grandé Viabilità per la Sicilia of ANAS
in Palermo
 - the plant in ^Tre Manzelli and works under
construction on the Palermo-Catania motorway,
 - the plant in Agrigento and works under con-
struction on the Agrigento by-pass,
 - the works under construction on the Ponte
Raisi - Mazara motorway.
- 4) University of Rome, Faculty of Engineering,
Institute of Highways, Railways and Airport Con-
struction, Rome,
- 5) University of Palermo-Faculty of Engineering, In-
stitute of Road Construction, Palermo,

- 6) Technical University of Padua-Department of Engineering, Institute of Building Bridges and Roads, Padua,
- 7) Technical University of Turin - The Science Institute of Construction, Faculty of Construction of Roads, Railways and Airports, Turin,
- 8) University of Pisa - Faculty of Engineering, Institute of Road Construction and Transport,
- 9) "SNAM - PROGETTI" S.p.A. - The Research laboratory of Petroleum Products, in Milan,
- 10) ESSO Standard Italiana - The Research Center in Rome,
- 11) ITALSTAT - Soc. Italiana per le Infrastrutture e l'Assetto del Territorio S.p.A. in Rome,
- 12) UNI - Ente Nazionale Italiano di Unificazione The Technical Office in Milan,
- 13) CNR - Consiglio Nazionale delle Ricerche - The Office of Study and Research Technology in Milan,
- 14) "Italconsult" - The Geotechnical Laboratory in Rome,
- 15) "Ing. Cassinis" - The Laboratory of Bitums and Soils in Rome,
- 16) "Geom. Belladonna" - The Factory of Bitumx and Soil Apparatuses in Rome.

2. Problems Talked Over

My subject of Study may be devided generally into two main groups of problems:

- the problems connected directly with the construction of road pavements,
- the problems related to a research aspect of asphalt binders and bituminous mixes.

Such way of study has been possible thanks to visiting as well as the firms which build roads, on the one hand, and the universities and research institutions, on the other hand.

Part. A. the Problems of Construction of Roads.

The problems of construction of roads were discussed specially in "Autostrade", SCAI and ANAS.

These institutions are the main performers of road works in Italy. It has allowed me to acquire with this subject very precisely.

"Autostrade" Company

The "Autostrade" is a main executor of motorways among the other companies in Italy.

This company includes into the group of IRI enterprises. Almost the half of all motorways have been built up to now by "Autostrade" company and subordinated to its executive units. "Autostrade" S.p.A. in Rome plays a role as a management in relation to its projective and executive enterprises. There are in Rome the Office of Technical Study and a Central Laboratory. I have been able to go into the next matters

during visiting this institutions

- 1) A general activity this company in the domain of construction of motorways.
- 2) The construction technology of motorway pavements which is applying nowadays as a result of hitherto experiences. I have been informed particularly about the technology as follows:
 - a) a construction of subbase which is made of
 - a natural stabilization
 - a stabilization of limestone crushed aggregate with the slag as a binder,
 - b) a construction of bituminous base of a "touvernan" type,
 - c) a construction of surfacing layers, i.e. a binder and a wearing course
 - d) a construction of hard shoulders.

The acquiring with the construction of pavement layers mentioned above has comprised the next details:

- the conditions of quality materials selection (mineral aggregates, asphalts and additives),
- the designing of a grading of the aggregate in connection with the destination of layers and in the case of wearing course especially in connection with the intensity of traffic,

- the designing of optimum asphalt content,
 - the standard quality requirements for mixes of sub-base and bituminous layers,
 - the conditions of production and setting bituminous mixes up (the accuracy of dosage, the temperature of production and compaction and so on)
 - the control methods of production and setting mixes up,
 - the quality requirements for a ready built pavement.
- 3) The designing of pavement structure and strengthening of existing pavements according to the method developed by the "Autostrade" Office of Technical Studies.
 - 4) Impermeabilization of the decks of bridges and viaducts.
 - 5) The getting to know in a practise with a work, activity and equipment of a central permanent laboratory and moving laboratory.

Moreover I have taken a great advantage of technical papers and journals at the local library which are not available in my country.

S C A I

SCAI belongs also to IRI Group and this is a specialistic enterprise for exercising bituminous works only.

I stayed directly at the sites of motorways.

In this case I could see the pavementation works on the great scale and machines used for these kind of works.

Particularly I have got learned about:

- 1) The production of bituminous mixes (for a base, binder and wearing course) in the two "Marini" plants; the one with a capacity of 250 tons/hour and the other - 60 tons/hour.
- 2) The construction of natural stabilization, base, binder and wearing course on the road and technical requirements for these kinds of layers.
- 3) the organization of works, namely:
 - at the base with ^{the} "Marini" plant [250 tons/hour]
 - on the road where bituminous mix was laid by means of two finishers ("Marini" and "Blaw-Knox") and rubber-tyred and steel rollers for compaction.
- 4) The work at the site laboratory
 - the control tests, i.e. the quality control of materials (aggregate and asphalt), the extraction of asphalt, the checking of compaction degree of materials on the road, the using of Marshall test for the control.
 - the designing of bituminous mixes in relation to their stability, impermeability and roughness.
- 5) The impermeabilization works on the viaducts with the using of special vapour release layer.

ANAS

ANAS is the main state administrative road unit and is directly responsible for the order and development of Italian road network. Except for administrative affairs it is dealing with maintenance and construction of roads.

Some research and experimentation works are also being carried on there. The Research Center in Cesano performs this last function. Apart from research works, the Center in Cesano fulfills a role as a central control laboratory for all contractors which are in co-operation with ANAS.

I had learned to know about all kinds of standard tests at the laboratory of the Center in Cesano and saw works under construction which were carried out by ANAS at its two provincial offices in Cosenza and Palermo.

Moreover, I have received broad information about the general problems of construction of motorways in Italy.

The Research Center in Cesano.

- 1) The tests according to the CNR standards:
N. 2, 3 and 7 - for asphalt, emulsions and cut-backs,
N. 4 - for aggregates.
- 2) The control tests for bituminous mixes (the determination of stability, flow, density, void, content of asphalt, gradation of aggregate).

- 3) Technological requirements for construction of subbase, base and surfacing courses which are in force for ANAS contractors.
- 4) Apparatuses for measuring of skid resistant of pavements (the British Skid Tester, the U.S. Skid-Trailer).
- 5) Experimental trials of nail guards.
- 6) The Burnister and Ivanov methods for dimensioning of flexible pavements.

The Office of ANAS in Cosenza

- 1) The production of bituminous mixes in the "Marini" plant with the capacity of 120 tons/hour.
- 2) The construction of brighten bituminous pavements in tunnels.
- 3) Impermeabilization works on the viaduct decks.
- 4) The different construction solutions of joints of bridges and viaducts which have been actually applied.
- 5) The construction problems of main engineering objects on the Salerno-Reggio Calabria motorway and on the Cosenza-Crotone state road N. 107.

The Office of ANAS in Palermo

- 1) The production of bituminous mixes in the "SIM Verona" plant with a capacity of 100 tons/hour.
- 2) The setting bituminous mixes up on a road (i.e. technological requirements during laying and compaction of mixes and organization these works).

- 3) Impermeabilization works on the viaduct decks, and construction of joints.
- 4) The construction of subbase with a natural stabilization and lean concrete.
- 5) ^The problems of utilization of mineral local materials for the road construction purposes.

University of Rome

I took part at the student excursion of University of Rome to see the works under construction on Naples by-pass.

Part.B. Research Problems.

My visits at some universities and at the ESSO, SNAM and Italstat companies have made mi possible to acquire with the research works connected with the asphalt binders and bituminous mixes which are actually carrying on in Italy. I have received many technical papers and publications and I was completly informed about the problems discussed.

Moreover I could see the laboratory outfit at these institutions what was very important for me.

The problems acquired are as follows:

I. University of Rome:

- Rheology behavior of asphalt concrete according to the traction test.

- Multi layer elastic system program for designing of structure bituminous pavements.
- 2) University of Palermo:
 - The effects of certain variables of composition on the properties of asphalt concrete according to the Marshall method.
- 3) University of Padua:
 - Development of a method for measuring adhesion of bitumen to stone and the importance of the rubber content in asphalt.
- 4) Technical University of Turin:
 - Determination by spectrometer of the percentage of bitumen in bituminous mixtures.
- 5) University of Pisa:
 - Skid Resistance measurement of bituminous pavings.
- 6) ESSO Company:
 - The preparation and properties of asphalt vulcanized with synthetic rubber.
 - The reactions and technological properties of sulfur-treated asphalt.
- 7) S N A M - Progetti:
 - The rheological behavior of bituminous mixtures intended for wearing course, binder and base under variable frequency of repeated loads at different temperatures.
 - The investigations of using synthetic rubber latices for the production of rubberized asphalt concretes.

8) The Research Center of ANAS:

- The effects of heavy overlays on the strength and skid resistance of existing pavements.
- Correlation of British Portable tester versus French Pendulum Tester for measuring pavement slipperiness.

9) Italstat:

- Performance of a range of bituminous mixes used in the wearing course of a motorway.

IV. Conclusions.

I find my professional training period in Italy has been very useful and I am completely satisfied with the ^{fact} ~~part~~ that my program of study is fulfilled as I may it estimate. The realization of the program was possible thanks to the help of people I met and their ~~a~~ proper understanding of my needs.

I have gathered much technical information, many books, research reports, articles and technological instructions. All of them are very important and I consider that they will be useful for me and my colleagues from my institution at the farther work.

I have ^Ientred into contacts and acquaintances with many people of the same proffesion. I appreciate this ^{fact} ~~part~~ and believe that it will be possible to keep these contacts on in the future.

Generally, I can draw the next main conclusions:

- I. A good network of roads and motorways especcially have the ^sgreatest influence on the growth of national

economy among the other means of transportation. Italy, it is the best example of this, where motorways are necessary for carrying over a heavy traffic at the industrial areas, and in the contrary, they contribute to an enlivening of the regions with a small economical activity.

2. Bituminous pavements are the most convenient for the construction of motorways from technological and economical point of view. The construction of such kind of pavements is cheaper and more speedy than the construction of cement concrete pavement, and even the maintenance is also more easy in some cases. These may be only the one exception in the case of roads with excessively heavy traffic.
3. The construction of bituminous pavements for motorways with high durability, stability and good skid resistance has to be done on the condition of using materials with good qualities and by means of automatic machines.
4. The different climate conditions in my country from Italian ones have to be taken into account during transferring Italian experiences in the construction of bituminous pavements.
5. Some new research works have to be under ^{in my country} taken to meet the actual and forthcoming needs in the designing and construction bituminous pavements.

Particularly, I find it necessary to put into effect the some improvements and undertake the indispensable works in my country, as follows:

1. To introduce some changes into the present hot-mit production technology of a asphalt concrete. Particularly, it concerns the principle of a dosage of component materials and temperature of heating aggregate and asphalt.
2. To introduce a supplement into Marshall method of designing bituminous mixes (the tests with variable number of blows of hammer and the control of flow in a time) and as well to revise the requirements at this method in order to obtain the mixes with the higher resistance against deformation under traffic.
3. To improve the extraction test for obtaining the better results of controlling the production of bituminous mixes.
4. To introduce the test of permeability of bituminous mixes during designing.
5. To apply the special insulation materials for the impermeabilization of viaduct decks (i.e. bituminous sheets, vapour release layers).
6. To introduce the viscosity test of asphalts on a larger scale for evaluation their quality.
7. To begin the investigations of asphalts with the additive of synthetic rubber.

8. To begin the research works of rheological behavior bituminous mixes under repeated loads of variable frequency in order to use the results of there^s investigations for the designing of ^{the} structure of bituminous pavements.
9. It is necessary to construct the structure of pavements of main roads for trucks with the load of minimum 11,5 tons per axle.

V. Acknowledgements.

I would like to express my gratitude to Technical Assistance Office of United Nations for awarding me and I am very grateful to my supervisor, dr. Massimo Begani from Istituto Nazionale per l'Incremento della Produttività for all the help he has given me.

I am also indebted^d to many persons from the institutions visited by me for their kindness and help during my studying. I would like to thank especially the next persons:

- prof. A. Benini, prof. G. Moraldi, prof. Giannini and eng. Cupo-Pagano from University of Rome, prof. G. Tesoriere and prof. S. di Mino from University of Palermo, prof. R. Bucchini from University of Padua, prof. Santagata from University of Turin, eng. Lancieri from University of Pisa, dr. C. Malenotti, dr. G. Silva, eng. G. Camomilla, eng. F.M. Franceschetti, eng. G. Peroni from "Autostrade" S.p.A., prof. C. Verga, eng. G. Battiato, eng. Bella from SNAM-Progetti, eng. F. Della Scala,

eng. E.G. Scotto, eng. ^{M.}Nuci, eng. De Luca, eng. ^{S.}Orlando,
eng. G. Orlando, eng. Lombardo, eng. Rizzuto, eng. Aloe,
eng. R. Foschi, geom. L. Marrazzo from ANAS, eng. M. Fer-
rari, geom. G. Meriggi, Mr. Trevisan, Mr. Pavaxelli from
SCAI, eng. U. Petrossi, eng. M. Pisani from ESSO, eng.
S. Frangulis, eng. A. D'Amato from Italstat.

eng. Janusz Zawadzki
/Poland/

4.06.1973.

N/R

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TECHNICAL ASSISTANCE OFFICE
Economic Commission for Europe
UNITED NATIONS

Date of award:

15 February - 15 May 1973

Name and home country:

Mr. B.A. KLOSINSKI, Poland

Field of study: Geotechnics and foundation
engineering.

Country (ies) of study:

United Kingdom

Bolesław A. Kłosiński, M.Sc.
Etudy Rewolucyjnej 15/17 m 25
02-643 Warsaw, Poland

F I N A L R E P O R T

on study in the United Kingdom

Subject of study: Geotechnic and Foundation Engineering
Period of study: 16th February - 15th May 1973

FINAL REPORT

On the study in the United Kingdom

Subject of study: Geotechnic and Foundation Engineering

Period of study: 16th February - 15th May 1973

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I - I am a civil engineer, specialized in bridge building. I have studied at the Technical University of Warsaw between 1955 - 61 and I have graduated as "magister engineer" (equivalent of M.Sc.).

After study I worked for two years as a lecturer at the Chair of Bridges at the Technical University of Warsaw.

I have been working at the Road Research Centre, Ministry of Transport, since 1962. This was formerly at the Bridge Division and lately as adjunct at the Foundation Laboratory.

The range of my activities comprises research and development works on the construction techniques of heavy deep foundations i.e. large diameter bored piles and diaphragm walls, site investigation, pile

and foundation load tests, elaboration or advising on bridge foundation design and supervision of construction, working out of codes and specifications on the site investigation as well as foundation design and construction, expert evidence on foundations etc. Several research works, and others, have been published, the results of which have been applied in construction practice in Poland.

I am a member of Polish Geotechnical Society and Society of Transport Engineers and Technicians.

II - The volume of industrial and residential buildings constructed in Poland has increased considerably during the last few years. The road traffic has grown up due to the beginning of a bulk production of popular cars, and to development of road transport. Consequently the development of motorways has started in 1973. Preliminary works on the construction of the underground in Warsaw, and in other cities eventually, have begun.

The rate of the building of these projects is controlled by the out-put capacity of Polish firms since the economy of Poland does not allow to employ foreign firms on a large scale. The realization of this task would not be possible, using conventional methods applied up to now. For this reason it is necessary to introduce the modern, more effective construction methods and to equip contractors with suitable plants.

The purpose of my stay in the United Kingdom was to study the modern foundation methods. The usefulness of these various methods in Polish geotechnical conditions would be analysed. The study would also enable us to recognize the value of plants and equipment used in the U.K., for use in Poland, which would condition their import.

The fellowship would give the opportunity to study design and calculation methods of foundations. Some of the British experiences in this field may be utilized in the preparing or renewing of Polish standards and codes.

III - The programme of study arranged by the British Council was foreseen as a three months stay with Tarmac Construction Ltd. of Wolverhampton. I was attached to this firm for only 6 weeks - from February 19th to April 2nd. During this time I was employed at the Central Engineering Department. I took part in the preparing of several designs, e.g. the sheet pile retaining walls of Mostyn Dock, the pile foundations of Levelyn Valley Bridge, the timbering of excavations at the railroad bridge supports at Brixton and the spread foundations of oil tanks at Aberdeen. I have visited some sites:

- March 22nd - at Hanley (timbered foundation excavation) and Wellington (road bridge and corrugated pipe culverts),

- March 28th - at Kidderminster (construction of the retaining wall and cable ground anchors) and at Dudley (grouting of the old mine shaft under the building to be constructed).

The range of foundation works I could cover with Tarmac was rather limited since this firm was not specialized in these works. I have come to the conclusion that the 6 week period is long enough for the design training and it would be more useful for my professional experience to join some other firms. Thanks to the assistance of Dr. K. Starzewski from the Aston University of Birmingham I have arranged the second half of my study as a series of short-time stays at foundation sites.

From April 3rd to 24th I was attached to GKN Foundations Ltd. I have visited 7 sites in the London area as well as Wolverhampton and Birmingham. I have observed the construction of small and large diameter bored piles, plate load tests in a borehole, belling out of pile bases and construction of driven cast-in-situ piles. I have had a good opportunity to get to know the piling plants being used.

During this period I took part in a 2 day course on 'Soil testing in site investigation' at the Aston University of Birmingham (10 - 11.4.73) and I have been invited to Filcon Engineering Co. works at Basingstoke - the producer of boring rigs and various site investigation equipment (18.4.73).

From April 25th to May 11th I was attached to Ove Arup and Partners Consulting Engineers. I was introduced into the structure and organization of this firm, which has its branches and jobs all over the

world. I have stayed on the Times Building site and Harrow-on-the-Hill Reservoir site, at which the ICOS diaphragm walls were used. Moreover I have visited Handon Station site at which I have observed the work of the Pilemaster machine, the National Exhibition Centre site near Birmingham and the Art Centre site at Barbican. I have participated in CRP load test of a pile and in the measurements of pile and raft loads under the multistory building at Knightsbridge. I have discussed some problems of foundation design with specialists of Ove Arup's Geotechnical Division.

The visit to the Building Research Station was arranged for me. I have seen the laboratories and I have been informed on the current works of BRS. The BRS supplied me with papers on the seminar "The behaviour and design of bored piles" and with other publications.

The observations during my study may be summarized as follows:

Site investigation methods do not differ very much from those used in Poland. Borings are frequently done by 'shell and anchor' technique. The equipment has been developed which mechanizes the casing operations and reduces the boring crew to two people only. The most widely used field test is SPT although some specialists consider it very erratic. The vane tests and the plate load tests are used too.

The static cone penetration and the pressuremeter tests are not popular. The standard diameter of undisturbed samples of cohesive soil is 100 mm.

The most popular laboratory tests are consistency limit tests, unconfined compression and quick (unconsolidated undrained) triaxial tests. The consolidation (uniaxial or triaxial) tests are seldom used in routine works. The triaxial test with effective stress analysis is widely used in case of long term stability problems. The laboratory vane is used fairly often.

The quality of site investigation is sometimes not satisfactory. The level of laboratory work is good as a rule. The form of working out of reports seems to be not so clear and comprehensive as it is in Poland. Reports usually include reasonable recommendations concerning the choice of solution for a particular foundation. Shallow foundations are beyond of the scope of this report.

Deep foundations are used frequently, even in relatively good soil conditions. There are many types of deep foundations and many proprietary systems for their construction.

The most popular type is pile foundation. In cohesionless soil driven piles are usually used. In cohesive soil - bored piles. The choice of a type of "piles to rock" depends on which type is easier to penetrate the overburden, and on the kind of rock. If a penetration into rock is required, the bored piles are used.

The exception is the piles penetrating into chalk, when the Vibro piles are thought to be the best.

The bored piles are widely used in the London area, where the soil conditions - mainly the London Clays - are especially suitable. The boring and casting of piles into the dry hole is usually possible in these soils. Boreholes of small diameter (up to 600 mm) are sometimes sunk using percussion tools (shell or clay cutter) on tripod rig with a power winch. There are small tripod rigs, needing only 2,5 m headroom. Almost always, however, piles are bored mechanically. For short and small diameter piles tractor-mounted augers are used, but for bored piles over 600 mm in diameter large truck or crane-mounted augers have to be used. These piles are often with an enlarged bell-shaped base. In the water-bearing strata, holes are bored by means of excavating rigs, using percussion tools and grabs, within heavy casing tubes. The ready-mixed concrete is generally used for cast-in-place piles on an urban site.

The applied working load depends on the dimensions of pile and soil conditions. They are from 40 - 100 T for small diameter piles up to and over 1000 T for large diameter piles. I have seen the piles, bearing the new YMCA House in London, which have had 2,0 m diameter shafts, with underreamed bases 6,0 m diameter. The working load of these piles was 5000 T for each.

The diaphragm walls are used mainly to protect excavations for deep spread foundations, or underpasses on traffic routes. They are used widely in the London area, where there are often existing buildings in the immediate vicinity of the excavation. The wall may act as a cantilever, may be supported at one or more levels by tie-backs, or braced with steel or concrete struts etc. It is common practice to use the ground level floor or more underground floors, if any, as bracing for the wall. The bracing or struts may be prestressed for the purpose of minimizing the wall movements and settlements of adjacent buildings.

The diaphragm wall may act simultaneously as a load bearing member. They have I, H, T or box section. These members are especially advantageous in the case of heavy lateral load and moment.

The diaphragm wall may be as much as 30 m deep. The wall is built in a mechanically excavated trench which has been filled with bentonite slurry to support soil during excavation. Reinforcement is dropped into the slurry and concrete is cast, beginning from the bottom of the trench, by tremie pipe. Pours should be completed in the shortest possible time and with minimum discontinuity. It was experimentally proved that the effect of bentonite film on the bond between steel reinforcement and concrete has no considerable influence if the good quality of the construction process is assured.

Some of the proprietary methods used in ^{the} U.K. are ICOS (Italian), Sole-tanche (French), and Terrephragm. The differences between them are not important, they are mainly in the equipment used.

Deep basements are constructed in a deep excavation supported by means of sheet pile or diaphragm wall. In urban areas sheet piles may be statically pushed into clay using the Pilemaster-machine. The advantage of this method is that it is relatively silent and vibrationless compared with driving sheet piles.

Excavation in clay is usually dug using the Caterpillar bulldozers. These machines are very effective and universal in application. Soil is removed by excavators or using belt conveyors.

The walls supporting the excavation are propped by tie-backs, steel or concrete struts etc. The tie-backs or struts are placed while excavation proceeds. They may be temporary or permanent members.

This excavation method has been successfully used during construction of some outstanding buildings in London e.g. Parliamentary House Garage, YMCA House and later the Post Office Tower.

Ground anchors are a special kind of tension pile of small diameter (150 - 300 mm usually). The pre-stressing tendon is placed in a drilled hole of an anchor and in granular material the hole is grouted. The penetrating grout forms a large body of concrete

around the hole. In clay soils underreaming is used in conjunction with specialised drilling and grouting technique. Underreams, at the base of the anchor, enable one to minimize the drilling length. After the hardening of grout, anchors are tensioned up to about 99 % working load. The typical working loads of anchors are 20 - 50 tons in soil and even 100 - 200 tons in rock.

Ground anchors are applied as temporary or permanent tie-backs for retaining walls, as a member assuring the resistance to buoyancy of docks or underground tanks and resistance to overturning of masts or transmission towers. Ground anchors may be also used to preload the ground under a foundation to minimize settlements of a structure, for pile and plate loading test instead of a kentledge, for slope stabilizing in rock, for the strengthening of dams and retaining structures etc. In some cases, especially in rock, the epoxy resin grout is used for anchors.

Construction of ground anchors is expensive, but in spite of high costs it pays to use them in many circumstances.

Design and supervision. Foundations are usually designed by consulting engineering firms. The requirements of standards and codes of practice are very general. They are much less detailed than in Polish standards. The design methods are based mainly on the experience of engineers, local experiences, and

generally accepted text-books and hand-books. The time for elaboration of design is very short as a rule. Designs are usually rather conservative. All designs must be approved by the district surveyor.

The quality of construction works is usually good. Works are thoroughly supervised. The supervision may be in behalf of a client, ~~main~~ contractor, consulting engineer or local authority.

Research. Some of the subjects of research undertaken at present in the field of foundation engineering are as follows:

- testing technique of bearing capacity and compressibility of a strong soil and a soft rock,
- methods of predicting the bearing capacity of pile based on the effective stress analysis,
- bearing capacity and settlements of groups of piles,
- predicting of retaining wall movements associated with large excavations, and of bottom heave of excavations,
- long-term stability of ground anchors in clay.

IV - The knowledge and experience, which I have gained during my study in the United Kingdom, will allow me, I hope, to introduce some novelties into the Polish foundation practice. I shall do it by advising and direct contacts with design and contractor organizations in frames of my activity in Road Research Centre, as well as by means of publications in professional periodicals and lectures.

The following investigation and construction methods may be used in Poland:

a. Site investigation

- plate load tests in test pits or boreholes, especially at the bottom of holes of bored piles,
- laboratory vane tests.

b. Piles

- bored piles 500 - 750 mm diameter, which may be constructed using relatively simple and light boring rigs with high out-put in suitable soil conditions,
- the use of rammed dry concrete for casting of the bottom part of bored piles,
- flat butts of Vibro piles, welded from a round plate and a ring collar.

c. Diaphragm walls

- precompressing of strutting members to minimize movements of the wall.

d. Grouting

- the use of cheap low-strength grouts (for example 10 parts of pulverized fly ash and 1 part of cement) for a preliminary consolidation of subsoil and filling the cavities.

e. Ground anchors

- the use of ground anchors as permanent or temporary members of structures,
- anchoring in concrete, brickwork or rock using epoxy resin anchors 10 - 30 and even 100 tons capacity.

The following equipment would be usefull in Poland:

- site investigation equipment, especially power driven boring rigs, automatic drop SPT hammers and laboratory equipment,
- hydraulic operated boring rigs for bored piles 600 - 750 mm diameter, produced in U.K. by several firms,
- the Pilemaster-machine pushing statically steel sheet piles,
- universal drilling rigs used for ground anchor construction and for investigation or grouting holes,
- equipment for instrumentation of earth dams, slopes or foundations: remote controlled piezometers, inclinometers etc.

British design experiences and research developments may be utilized, especially in the field of:

- design of bored piles in cohesive soil, diaphragm walls and ground anchors,
- prediction of movements of large excavation walls (braced, anchored or cantilever),
- in a limited range - British standards and codes.

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Acknowledgements

I would like to express my gratitude and thanks to:

- Technical Assistance Office of United Nations for awarding me the UN Fellowship in the United Kingdom
- The Government of the United Kingdom for the possibility of staying in this country
- the Polish Government for appointing me as the candidate for the Fellowship
- the British Council and personally Miss P.F.Wells - my Programme Organizer - for arrangement of my study
- Tarmac Construction Ltd. and personally Mr.J.A.Statham - for his kind attention during my stay with this firm
- GKN Foundations Ltd., Ove Arup and Partners Consulting Engineers for enabling me the useful practice on their sites
- Dr. K.Starzewski from Aston University of Birmingham for the admission to course on soil investigation and the assistance in arrangement of second half of my stay

and to all persons in this country who contributed to my acquiring the knowledge of the subject and whose benevolence I have met during my stay.

B.K. Wozniak

London, May 15th, 1973

W/K

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ECONOMIC COMMISSION
FOR EUROPE

Mrs. Shoukletovich

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



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RECORDS CONTROL

JUN 8 1973

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

TECHNICAL ASSISTANCE OFFICE
Economic Commission for Europe
UNITED NATIONS

Date of award:
4 January - 5 May 1973

Name and home country:

Mr. J.H. RZEPECKI, Poland

Field of study:

Technical solutions for
securing flexibility of large
power sets.

Country (ies) of study:

United Kingdom

FINAL REPORT OF THREE MONTHS STUDY IN
GREAT BRITAIN ORGANISED BY THE UNITED
NATIONS FOR

JACEK RZEPECKI

ENGINEER IN THE RESEARCH & DEVELOPMENT
OFFICE OF THE MINISTRY OF MINING AND
POWER IN POLAND

FINAL REPORT

This report is the result of three months study in Great Britain organised by the United Nations. The programme of the study was sent to the United Nations by Polish Government and was confirmed by the United Nations.

This final report is made according to the instructions sent by the United Nations.

The subject of my study during my stay in Great Britain was "The Problems connected with Technical Solutions for securing flexibility of large turbines".

The duration of my stay in Great Britain was from 4th February to 4th May, the period 4.1.73 - 4.2.73 being spent studying the English language in Pitman's School in London.

To enable me to study the above mentioned subject in Great Britain my name was put forward by my Government to the United Nations.

In my home country I am a Mechanical Engineer having studied for six years at Polytechnic Gdansk where I specialised in steam turbines. Since leaving Polytechnic in 1955 I have been employed in the Research and Development Division of the Ministry of Mining and Power. Initially I was assigned to work connected with turbine control systems and with research into the dynamics of the turbines. Since 1965 I have been involved with development work connected with the controlled start-ups of large steam turbines. This work included visiting various power stations where tests were being carried out, analysing these results in my office and then preparing an optimal working programme. At present I am a Chief Specialist occupied mainly with work directed to the increase of turbine flexibility and towards the improvement of the operating conditions of turbine/boiler units.

In my home country there has been in operation for approximately the last 10 years large reheat turbine/boiler units of capacity 120 and 200 M.W. These units operate at very high temperature and pressure conditions and in fact the materials of which they are constructed are operating very nearly at their maximum limits. This material problem is not only associated with

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the large generating units in my country but is a common problem in all countries where large turbo-alternators are in service. Therefore, it is very important that all start-ups are controlled very carefully to ensure that safe limits are not exceeded and that the start-up is carried out in the optimum time. This is especially important for two shift working ie when the turbines are being shut down overnight due to the demand on the Grid system being very low because of the absence of industrial load. Where turbines are operating on a two-shift basis the metals are subject to thermal cycling ie they are being repeatedly heated and cooled. This heating and cooling can produce cracks in the metal components especially where the metal changes thickness or where welding has been used in the construction.

My study subject is concerned with operating the large units in my country safely and efficiently especially when we begin two shift operation regularly. For this reason I chose to study in Great Britain to enable me to profit from the experience gained there due to the considerable amount of two shift working of large sets being carried out.

Items for special attention:-

- (1) Actual instructions and criteria for the optimum start up conditions for turbine/boiler units.
- (2) Calculations and experimental determinations of thermal stresses in turbine and boiler components.
- (3) Experiments made on a base load turbine to adapt the turbine for frequent two shift operation.
- (4) Any constructional changes made to the basic turbine for two shift usage.
- (5) Defects to items of the equipment caused during any transitional stages.
- (6) Economical aspects of frequent start-ups.

A study of the six points mentioned above will enable me to assist in the solution of any problems which might arise when we start two shift operation on a regular basis in Poland.

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My period of study in Great Britain was spent in Scotland at the locations detailed below:-

(1) South of Scotland Electricity Board (S.S.E.B.)

- (a) Headquarters, Glasgow 5.2.73.
- (b) Dalmarnock Power Station 6.2.73 - 9.2.73.
- (c) Kincardine Power Station 10.2.73 - 30.3.73.
- (d) Longannet Power Station 31.3.73 - 6.4.73.

(2) North of Scotland Hydro-Electricity Board (N.S.H.E.B.).

- (a) Carolina Port Power Station, Dundee 7.4.73 - 13.4.73.

(3) S.S.E.B. Headquarters

- (a) Generation Design and Technical Services Dept. 14.4.73 - 19.4.73.

The following is a detailed description of my work in the places where I studied:-

1a. S.S.E.B. Headquarters

During my visit here I was given a general insight into the operation of the Electricity Supply Industry in Great Britain and in particular Scotland. I also discussed a programme for my studies and made arrangements to attend the different places.

1b. Dalmarnock Power Station

My introduction to my study was a four days stay at Dalmarnock Power Station - a station which is operating small capacity turbines on a two-shift basis. In the power station I familiarised myself with all the equipment, especially the turbines and I discussed with the engineers the tests which had been carried out to prepare the turbines for two shift working. In addition, I observed the start up and shut down procedures for the 50 M.W. turbines.

Of particular interest was the information I received about the cracking of turbine discs which was taking place near the shaft keyways on some 60 M.W. sets in other stations. Similar 60 M.W. sets are installed in Dalmarnock Power Station.

1c. Kincardine Power Station

The main part of my study time was spent in Kincardine Power Station. This was of great benefit to me because in this station there are turbines similar to those in my own country. The first set was commissioned in 1958 and today the power station, which consists of 3-120 M.W. units and 2-200 M.W. units, operates on a two-shift basis. The running of the turbines depends upon the requirements of the Grid System.

Before the units were operated frequently on a two-shift basis tests were carried out on a 120 M.W. and 200 M.W. unit. All the information about the construction of the sets, the tests carried out on the sets, the start-up procedures, and the defects arising out of 2-shift work were made available to me to study.

My study consisted of:-

- (i) Studying all technical documentation.
- (ii) Acquainting myself with the plant layout.
- (iii) Acquainting myself with the instrumentation used during the start-ups.
- (iv) Observing start-up procedures, both hot and cold starts.
- (v) Study reports of defects which could have arisen from two-shift operation.
- (vi) Acquaint myself with the turbine/boiler components which are liable to suffer damage from cracking, and also to study methods of crack detection.
- (vii) Study operating documents relating to the semi-automatic equipment fitted to units 4 and 5 (200 M.W. sets)

Explaining the above points in more detail:-

From all the technical documentation I was able to study the constructional methods used to ensure good, safe and efficient start-ups of the turbine, for example the heating of the turbine metals during start-ups, especially cold and warm starts. Two examples of these methods are the use of flange heating and the warming of the main steam legs to the turbine.

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Having studied all the information relating to the plant, I next spent some time in the plant familiarising myself with the layout of the equipment - especially the equipment to measure the temperature of metals and steam. It was also important that I knew where thermocouples were fitted because it is essential that only truly representative temperatures are measured. Also of particular interest was the overhaul being carried out on Turbine No.2 (120 M.W.) as it enabled me to inspect in more detail the internal construction of the turbine valves and cylinders and also the points where the temperatures are measured.

I next spent some time in the Unit Control Rooms acquainting myself with the turbine and boiler instrumentation, such as pressure, temperature, vibration, eccentricity and level indicators and recorders. I was able to compare this instrumentation with the similar equipment we use in my country.

During my time in Kincardine I observed many start-ups on both the 120 M.W. and 200 M.W. turbines. There were start-ups from cold when the temperature of the turbine was below 300°F and start-ups when the turbine was hot after standing for a very short time - up to 10 hours.

I was particularly interested in any methods used to avoid exceeding limits and also in the procedure for the start-up. I received from the power station the start-up procedures for hot and cold starts for the 120 M.W. and 200 M.W. turbines and from these I will be able to compare the main points with the same procedures used in Poland.

From several start-ups I collected details such as extracts from the control room log book, charts from the recorders for pressures, temperatures, eccentricities etc and by an accurate analysis of these details I was able to observe how near to the limits the turbine was during the start-up. At each turbine overhaul checks are made on various components and parts to see if any cracking of the metal has occurred. I studied reports of these checks and noted that after approximately 5 years of two-shift working on the 120 M.W. turbines cracks have occurred at certain pipe welds and also on valve chests and seats.

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While I was at Kincardine these checks for cracks were being made on No 2 turbine which was on overhaul and up to the present time no new cracks or defects have been discovered. Thus, as yet no serious defects can be attributed to two shift working.

The main points to be checked on the unit are where there is a rapid increase in temperature during start-up, for example the main steam pipes and the valve chests. Cracks may be found where there is a large mass of metal, where the metal changes thickness and where welding is used - and it is at all those points that the crack detection tests are carried out.

Before any crack detection can be carried out the surface of the metal must be cleaned. Following the cleaning, the crack detection methods used are Ultrasonic, dye-penetrant, and magnetic particles.

During my period of study at Kincardine all start-ups on the 200 M.W. units were carried out manually although semi-automatic equipment is provided. This S.A. equipment operates only the turbine and not the boiler which still has to be manually operated. The turbine semi-automatic equipment was installed especially for shut-downs and hot starts. When I was in the Plant Control Room the S.A. equipment was demonstrated to me. At present it is not used because of its unreliability and maintenance problems. On the subject of semi-automatic equipment I only studied the operating documents and not the constructional information as there was not sufficient time available. In fact, the semi-automatic equipment could be a separate study subject on its own.

1d Longannet Power Station

In order to become further acquainted with the problems connected with the operation of large turbines, I studied for 5 days at Longannet Power Station. This power station, unlike Kincardine, is a base load station and consists of 4 turbines (cross compound) each with a capacity of 600 M.W.

While at this power station, and because of the short duration of my visit, I concentrated my attention particularly on the plant, documents and all problems connected with turbine start-ups.

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As in Kincardine Power Station, the most important aspects for me at Longannet were:-

- (a) Start-up limits due to temperature conditions.
- (b) The methods used to control these limits during start-up.
- (c) Any special items of equipment or construction to reduce the effects of temperature differentials during start-ups.

The short study of the above aspects has given me a greater insight into some of the problems connected with the operation of large turbines.

2a Carolina Port Power Station

The five days which I spent in Carolina Port Power Station were to me very interesting and important because in the station are installed 2 - 120 M.W. turbines manufactured by A.E.I. These turbines are very similar to those manufactured in my own country under licence from A.E.I.

During my stay at Carolina Port, I studied some interesting documents, familiarised myself with the plant layout and the instrumentation associated with turbine start-ups.

When I was in the power station I studied documents relating to any tests, plant modifications etc which have been made before commencing two shift operation of the turbines.

3a S.S.E.B. Headquarters

The last period of my studies (4 days) I was in S.S.E.B. in Generation Design and Technical Services Department.

In that short time acquainted with the way to investigations, results of investigations and all instruments which are used to those investigations. I also was generally acquainted with methods to determine stresses in metal of turbines.

During my stay in Britain I have acquired knowledge and experience of the methods used in the start-up of large turbines and also of any changes being introduced with the object of increasing flexibility and improving the operational conditions of the turbines.

This technical and practical knowledge which I have acquired during my stay with the S.S.E.B. will be utilised in the power stations in Poland to improve the availability and the economic operation of large turbines.

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FOR EUROPE
RECORDS CONTROL

Mrs. Shoukletovich

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

JUN 8 1973



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

TECHNICAL ASSISTANCE OFFICE
Economic Commission for Europe
UNITED NATIONS

Name and home country:

Mrs. L. BERNER, Poland

Field of study: Traitement électronique des
informations.

Date of award:

1 February - 28 April 1973

Country (ies) of study:

Belgique

Rapport de stage

Lidia BERNER

STAGIAIRE POLONAISE

du 1.2.73 au 28.4.73

R A P P O R T D E S T A G E

Lidia B E R N E R

Stagiaire polonaise

RAPPORT FINAL

- I. Un bref exposé de mes attributions dans mon pays,
accompagné d'une description succincte de la forma-
tion que j'ai reçue et du caractère particulier de
mon activité antérieure.

Je travaille à l'Etablissement de la Technique Electronique à Lodz comme projeteur supérieur, c'est-à-dire comme analyste informatique et ordinarique supérieur des systèmes de traitement automatique des informations.

J'ai fait mes études à l'Université de Lodz et ensuite j'ai suivi à Varsovie le cours organisé par le Centre Polonais de Perfectionnement des Dirigeants (C.O.D.R.K.) pour les projeteurs des systèmes de traitement automatique des informations.

Mes attributions fondamentales sont les suivantes :

- la direction des travaux du groupe. Celui-ci effectue les projets des systèmes de traitement automatique des informations;
- la participation aux travaux de ce groupe;
- la réalisation des travaux analytiques et programmes donnés par le Chef direct;
- l'analyse du progrès des travaux de mon groupe et l'information du Chef direct concernant la marche du travail et les mises en concordance avec les client
- la description du travail fait selon les principes obligatoires.

Les systèmes du traitement automatique qui sont réalisés par mon groupe améliorent la gestion des entreprises et contribuent à les diriger avec succès.

L'établissement des projets des systèmes de traitement automatique se fait en deux étapes :

- macro-projet
- micro-projet

Au cours de la première étape, on prépare les principes pour le système futur :

- étude préliminaire de l'entreprise;
- formation du modèle général pour l'économie et l'organisation
- fixation de l'esquisse des circuits d'information et de l'ensemble des moyens techniques.

Le projet technique constitue la deuxième étape :

Dans ce projet on présente la forme des documents d'entrée et de sortie, la structure des fichiers permanents et ouvriers, les algorithmes de traitement, les schémas du fonctionnement, les modèles économiques et mathématiques et les marches de traitement des informations.

De plus, le projet du système doit être assez élastique pour que l'on puisse introduire les changements inévitables résultant des besoins actuels des utilisateurs.

Il en résulte, que le rôle du projeteur (l'analyste informatique et ordinarique) est très difficile et exige :

- capacité de s'entendre convenablement avec l'utilisateur
- bonne connaissance de l'entreprise
- bonne connaissance du traitement électronique des données
- capacité de persuasion
- augmentation continuelle des qualifications professionnelles en se mettant au courant des projets élaborés et de la littérature et en prenant part aux cours de perfectionnement professionnel.

II. Un résumé des problèmes particuliers de mon pays qui ont incité mon Gouvernement de me désigner comme titulaire d'une bourse de perfectionnement offerte par l'Assistance Technique des Nations Unies, étant entendu que mon stage contribuera à l'amélioration de la situation nationale.

Dans notre pays l'informatique est un domaine très jeune, qui se développe constamment et cause beaucoup de difficultés.

Le but de ce stage est d'obtenir une meilleure connaissance de l'établissement des projets de traitement automatique des informations efficaces et élastique surtout dans le domaine de l'industrie, du commerce et de l'administration.

Mon pays adopte la composition d'un système automatique national dont la caractéristique principale sera la recherche des dépendances macroéconomiques.

De la sorte, mon bureau s'allie aux tâches du Gouvernement polonais. Il y participe grâce aux travaux de composition d'un système automatique national.

C'est ainsi que la Société où je travaille et ensuite mon gouvernement m'ont désignée comme titulaire d'une bourse de perfectionnement pour résoudre les problèmes nécessaires à la réalisation de notre tâche. En particulier le stage à l'étranger devra me permettre d'obtenir des connaissances sur les problèmes détaillés ci-après :

1. l'établissement de projets des systèmes du traitement de l'information en particulier des systèmes du commerce profitant de la banque des données.

- 1.1. Les aides techniques et celles du domaine de l'organisation du travail du projeteur et du programmeur.
 - 1.2. La collaboration avec le client dans le centre, qui fait des projets de systèmes (formes de concordances).
 - 1.3. Les étapes du projet et un standard de la documentation du projet à ces étapes
 - 1.4. Le sort ultérieur du système de mise en place (chargement et amélioration)
 - 1.5. Les méthodes d'estimation préliminaire du temps d'élaboration du projet de système et son effectivité (vérification de cette estimation au cours du projet)
2. Connaissance des systèmes de mise en place concernant le commerce et l'administration
 - 2.1. Les installations qui organisent le travail dans un bureau et préparent les supports des données (cartes, rubans, bandes magnétiques).
 - 2.2. Les solutions de systèmes dans le domaine :
 - de la recherche de la demande et de l'offre
 - du marketing
 - de la banque de données.

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III. La description du programme d'observations et d'études élaboré par l'assistance technique des Nations Unies et du pays hôte, la Belgique.

Mon stage en Belgique a duré du 1er février 1973 jusqu'au 28 avril 1973.

Mes études se sont poursuivies de la manière suivante:

1. du 1er février au 28 février :

J'ai suivi le cours " Management of Systems Analysis" organisé par I.B.M. au Centre d'Education à Ottignies. Le programme de ce cours comportait les phases décrites ci-après :

A. Méthode (37 % du temps du cours)

- DP Decisions
- DP Evaluation

B. Technique/outils (29 % du temps du cours)

- Générateur de programmes de simulation
- Recherches opérationnelles
- Contrôle de projet (PERT)
- Théorie de la décision

C. Techniques ordinatiquies (13 % du temps du cours)

- Concepts of operating systems
- T O S (conception)
- Banque de données (conception)
- Evaluation du temps de la programmation

D. Formation générale (31 % du temps du cours)

- Temps work. Human relations. Motivation
- Présentation technique
- Technique du rapport
- Decision making
- DP Organisation.

2. du 6 février au 9 février 1973

J'ai visité le Centre IBM à DIEGEM où j'ai reçu des informations concernant l'"Information systems Manager" pour la Société IBM

J'ai parcouru les départements décrits ci-après :

- Planning et contrôle qui a pour mission d'effectuer les plannings opérationnels et stratégiques.
- DP Services - Exécution qui a pour mission d'effectuer les différents travaux d'exécution sur machines, c'est-à-dire, d'exploiter le matériel ordinaire.
Son chef de Service dirige trois bureaux :
 - le bureau de Planning et de Contrôle,
 - le bureau de l'ordinateur
 - le bureau d'enregistrement
(l'enregistrement des données par perforatrices de cartes avant leur traitement par les ordinateurs).
- le Groupe d'Application qui est chargé de modifier le système présent et de bâtir les applications futures. Les programmeurs sont chargés de la programmation à partir des dossiers d'analyse établis par les équipes de projets.
- Support de systèmes - cellule " Coordinator Standards"
Cette cellule est chargée d'établir et de diffuser les méthodes, les règles et la documentation standard.

3. du 20 mars au 28 avril 1973

Pendant cette période, j'ai collaboré avec le Centre du Traitement d'Informatique de la Société " PRIBA-INNOVATION - BON MARCHE " à Bruxelles.

De cette collaboration je me suis mise au courant des problèmes suivants :

- l'organisation des grands magasins et l'organisation de leurs entrepôts (Forest, Ternat et Zellik)
- les systèmes du traitement d'informations qui sont de mise en place :
 - le système de la gestion de l'entrepôt "PRIBA-INNOVATION-BON MARCHE"
 - le système du Kimball (système de contrôle unitaire commun dans les rayons)
 - le système des " grosses pièces " (avec les carts spéciaux)
 - le système des caisses, qui produisent le ruban de papier à " lecteur optique"
- le dossier d'analyse et le dossier de programmation. Ceux-ci sont créés et utilisés par le Centre du Traitement d'Informatique.
- la petite application du marketing
- l'application du télétraitement dans l'entrepôt

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IV. Mon opinion sur la mesure dans laquelle ma formation à l'étranger dans ma branche pourra contribuer au progrès de mon pays.

Mon stage en Belgique a permis de développer ma compétence professionnelle et d'être mieux aux fonctions et responsabilités, qui me seront confiées lorsque je rentrerai dans mon pays.

Mes études à l'étranger ont aidé à obtenir de meilleures connaissances sur les problèmes suivants :

- méthodes d'analyse des problèmes du système d'information et du système informatique dans l'entreprise.
- dossier standard sur chaque étape d'analyse (décision, la conception et l'exploitation)
- organisation du centre du traitement automatique des informations et du travail de différents services dans ce centre.
- connaissance des systèmes de mise en place concernant le commerce :
 - le système de la gestion d'un entrepôt : - achat
 - vente
 - entrepôt
 - administration
 - le système des " grosses pièces"
 - le système du Kimball
- installations qui organisent le travail dans un bureau et préparent les supports des données
 - système M D S
 - système de caisses N C R
 - système du " lecteur optique"
- application du télétraitement dans l'entrepôt

- petite application du marketing.

Je suis persuadée que ce stage m'aidera de façon valable à contribuer au développement de l'informatique de mon bureau ainsi que de mon pays.

En guise de conclusion, je dirai que mon stage en Belgique était très varié et très intéressant. J'y ai trouvé une atmosphère véritablement amicale et agréable, une très bonne collaboration de la part des personnes qui se sont chargées de mon stage et qui se sont donné beaucoup de peine pour l'organisation de mon programme d'études.

Je remercie le personnel de l'Administration générale de la Coopération au Développement, les Nations Unies, I.B.M. ainsi que la Direction et les collaborateurs de la Société PRIBA-INNOVATION-BON MARCHE.

Fait à Bruxelles, le 25 avril 1973.

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POUR L'EUROPE

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TECHNICAL ASSISTANCE OFFICE

Economic Commission for Europe

UNITED NATIONS

Date of award:

28.9 - 7.4.
1972 1973

Name and home country: Mr. Z.L. ZAGORSKI
Poland

Field of study:

Application of mass produced steel
building components

Country (ies) of study:

U.K.

Zygmunt Zagorski
ul Szczesliwicka 19 m 58
02-352 Warszawa
POLAND

FINAL REPORT OF STUDY IN UNITED KINGDOM

Professional background: Structural engineer specialising in designing steel structures for industrial buildings.
Chief of the design team in Central Office for the Design, Research and Development of Industrial Buildings.

Present assignment: Nominated by Polish Government for a United Nations Fellowship in a connection with the development in Poland of the light steel structures and the light cladding for the industrial buildings.

Programme of work: The programme of research and study devised by the United Nations and United Kingdom Government covers the programme envisaged by Polish Government.

The title of work: The subject of study "Application of mass-produced steel building components."

For practical purposes the major work has been sub-divided into four major sub-sections:

1 Structure 2 Roof 3 Wall cladding 4 Structural inter-relation between structural frame, roofing and wall cladding.

At this point of the study wall cladding element is separated from roofing element in spite of the prevailing opinion that wall cladding and roofing form an integral entity of the external envelope.

It is accepted that wall claddings and roofing elements have a common function of a protective and weather resisting envelope but at the same time such simplification of common performance may lead to the faulty conclusions and to the wrong solution.

For this reason it is very important to consider the separate functions and differences between these major elements ie roofing and wall cladding.

- Horizontal and inclined planes of roofs are more exposed to the exigencies of weather conditions than vertical wall cladding.
- Roof and roof structure apart from its own (dead) load has to take additional super-imposed load of snow and the occasional point loads of men (maintenance team) and/or overhead cranes.
- The failures in the roofs are more critical to the users and affect the production more than the leaks in the walls.
- The vapour pressure and condensation inside the building is more likely to occur on the roofing than on the wall cladding.
- The assembly of the roof components requires more involved equipment, the minimum being the light hoisting equipment whilst the lightweight wall components may be assembled on site by hand.

The report considers in depth the problems of external envelope with particular attention being paid to prefabricated components. In this field of development there are still conflicting views.

2 THE STRUCTURE OF THE BUILDING

For many years the engineers of many countries, worked to find the structural systems for industrial buildings integrated with the light cladding employing industrialised components. The problem of structural systems is difficult to resolve because simultaneously with the progress in other fields of technology and the sciences like psychology, sociology, ecology etc as well as changing views on our future demands and life pattern create new rules for the design in other spheres of technology.

The building industry is not only affected by the above factors but also by the demands of manpower resources which do not meet the national requirements.

Therefore, greater use must be made of factory methods, components and modern techniques to fulfill the required programme.

It is important to create well developed systems of industrial buildings which would provide a better integration between basic structure, cladding, services and cost-in-use.

The philosophy of factory systems sees the "factory" in-toto as highly controlled product and immediately available for direct consumption.

The factory systems are trying to be all things to all producers. But various productions have different technology and need different services. It is also impossible to get a precise answer of the real problems of adaptable space required by modern factory as well as information about services in future.

It is only possible to resolve the problems of the factory buildings when we have set out the correct criteria for them. There are however, within the criteria some contradictions to the behaviour of materials in use.

For that reason, designer teams working in different conditions and being in different stages of technical development give varying criteria and priorities. However, at the present stage of development the common recognised design criteria for the system factory building are as follows:

- Economy which consists of the following sub-elements of cost
 - a basic material
 - b conversion with protection against corrosion
 - c transport
 - d assembly as well as cost of the maintenance in use.
- Convenient transport of the elements.
- Quick and safe assembly.
- Integration of the structure and services such as ducts, vents, and overhead cranes.

Most factories ought to be served from roof level and not from the floor, because the services from the roof have higher degree of adaptability than services in the ground.

- Flexible method of bringing factory services to all parts of the building, including power and lighting, gas, compressed air and water, planned daylighting and artificial lighting.
- Possibility of modifications to meet changing production needs ie adaptability.
- Large free spaces. Common used in structure systems of industrial buildings are spans 12 m at column centres 12 m with tendency to increase to 18m.
- Flat roof with the flat bottom ties of the lattice girders for supporting and control factory services. Facilities for the fitting up of suspended ceilings.

- In modern factory built for unspecified producers and for the unknown production line, roof structure ought to have always the ability to lift small loads of up to one or two tons at various well defined points. Additionally the use of forklift truck ought to eliminate inflexible and traditional column layout which supported overhead electric travelling cranes.
- In a lot of cases floor slabs and screeds should be strong enough to allow direct lorry access into the building.

The last requirement is of course closely connected with the problem of load bearing of ground.

The most common contemporary steel structures for industrial building are as follows:

- lattice beams
- portal frames
- roof space frames

I am not going to describe the advantages and disadvantages of these particular structures, their method of the production, transport, assembly and maintenance, as these are well known, but I would like to express my opinion in what situations the preferences should be used.

In my view the framed space-structures should be employed in such buildings as sport and exhibition halls, and in the types of industrial buildings in which it is possible to define in advance the exact location of suspended point loads and of the openings in the roof.

In industrial halls in which it is difficult to define the future loads and the locations of services or overhead cranes and which require higher degrees of adaptability, the better solution is to employ the lattice beams.

Portal frames should be mainly used for the buildings which do not need many service ducts under the roof, and the centres of columns may be closer in relation to the spans of structure.

I feel that for industrial buildings which have to be equipped with overhead cranes and are required to have similar centres of columns as the span, the better structural solution is trussed grid (system used very seldom). This type of structure has many advantages because of a high degree of stiffness and possibility of making large openings in the roof. This structure offers ease of suspending services under the roof, has all the bottom chords at the same level and may be assembled quickly.

3 THE ROOFINGS

3.1 General Information

The roofing, though integrally connected with the structure of the building, creates a different problem. To make it easier to consider the problems connected with roofing, I will analyse separately two main types of roofing ie sheeting in which metal sheets form outside layer and decking where the metal sheets form the bottom layer with thermal insulation and the weatherproofing layers above.

In both types of the roofing it is necessary to consider the same problems: thermal conductivity and the condensation.

The first problem does not offer special difficulties both in the design stage as well as during erection of the building, so I am passing over this problem. But I would like to consider the condensation and the difficulties connected with this phenomenon. The air moves from the warmer space to the colder space, because of the pressure differentials. This phenomenon occurs in the roofing as well as in the wall cladding.

The warm air on its way meets the cold vapour barrier and the temperature of the air will decrease to the dew point, the vapour contained in the air will change into water.

In this situation the thermal insulation inside the roofing may get wet and will lose its thermal insulation properties. Therefore, the main principle is to design an outside layer on the warmer side of the roofing to act as vapour barrier to protect the thermal insulation from the moisture. It is of course important to allow such thickness of the thermal insulation that it will prevent condensation occurring on the surface of the ceiling.

3.2 Metal Sheetting

3.2.1 Introduction

Metal sheetting should be used mostly for roofs which do not need the thermal insulation and have the slopes about 10° or more. It is necessary to stress the possibility of using sheetting on roofs with lesser slopes. In such a case it is advisable to use the sheets as long as the slope of the roof with adequate seal of side laps. In the case of using shorter sheets than the slope of the roof, it is necessary to seal also end laps. These principles should be also employed in metal sheetting with thermal insulation forming an integral part.

Metal sheettings are particularly suitable for north-light roofs. The construction of the metal sheetting without thermal insulation is very simple in contrast to the metal sheetting with insulation. For that reason I will deal here only with the second type of the sheetting.

The main types of metal sheetting with thermal insulation are as follows:

- sheetting assembled on the building site using separate layers
- sheetting assembled using factory made components.

3.2.2 Sheetting assembled on the Building Site using the separate layers

The good example of this type of roof seems to be sheetting which consists of the following layers: metal sheets, glass wool, plasterboard faced two-sided PVC and aluminium foil. The bottom layer (plasterboard) is fixed to the steel cold rooled "T" sections stuck to the purlins.

The second layer, the glass wool insulation, should be the quilt variety (rolled) and not a slab type. The metal sheets forming the outside layer may be fixed to the purlins through the timber fillet.

It is necessary to stress the following requirements:

- If in the building there is a high percentage of moisture the junctions between the steel "T" sections and the plasterboard ought to be sealed with butyl mastic, for example.
- From the aesthetic point of view it would be advisable to face the "T" sections from inside of the building with PVC strips.
- The metal sheet used on the outside layer ought to be protected against weather conditions.
- The profiled steel sheets ought to be fixed to the purlins every second trough using corrosion resistant self-tapping screws and plastic washers.
- The side laps of the sheets ought to be connected by pop rivets at centres of about 500 mm.
- It is necessary to check the deflections of the metal sheets not only for continuous loads due to dead load as well as the live load but also the deflection due to the point load of about 100 kg loading over the area of about 30 x 30 cm. This particular deflection should be considered when selecting sheet section profile and span to avoid the possibility of joint failure and subsequent water penetration. In this type of roof the deflection of the metal sheet should not be more than $\frac{1}{120}$ of the span. The maximum deflection for uniformly distributed loads should be calculated using one or other of the following formulae:

$$\text{Single span case } \Delta_1 = \frac{5}{384} \frac{WL^4}{EJ}$$

$$\text{Double and triple span cases } \Delta_2 = \Delta_3 = \frac{3}{384} \frac{WL^4}{EJ}$$

The coefficient $\frac{3}{384}$ in the expression for deflection in the double and triple span cases makes a reasonable provision for non-uniform distribution of loads, as occur for example with drifting snow around roof obstructions. The coefficient is arbitrary but follows already widely accepted practice both in the UK and USA and for this reason may be adopted also in other countries.

3.2.3 The sandwich panels have become, over a number of years, the popular method of enclosing buildings with sheet based material. The "sandwich panel" may consist of an outer layer of metal sheet backed by polystyrene foam, polyurethane foam or another form of insulation. The inner-face consists of either a second sheet metal layer or plasterboard or some other type of lining. In these types of components it is very important that the proper adhesion exists between individual layers. It is possible to get the appropriate adhesion in two ways:

Firstly it is possible to use an adhesive to bond outside layers to the core. A more popular technique is to use the polyurethane foam as an expanding mass between two outside layers and adhesion is obtained by the setting foam bonding to the outside layers. It is necessary to stress that in both ways, metal sheets should be specially treated prior to manufacture to ensure good surface adhesion.

There are four basic design principles for these components:

- Facing of sandwich panels must be at least thick enough to withstand chosen design stresses for the total design loads of the sandwich.

- The core shall be thick enough and have sufficient shear rigidity and strength so that excessive deflection or shear failure will not occur under design loads.
- The core shall have a high enough planar modulus of elasticity and the sandwich shall have sufficient planar tensile strength and compressive strength so that wrinkling or other facing failure will not occur under the design loads.
- To meet necessary conditions it is assumed that the panel is assembled so that facings and core will respond under loads as required.

CAUTION: a Components should be designed as simply supported. Continuity is not expected to reduce deflections as these are largely due to shear in the core. Two way spanning would, however, have some advantages.

b A factor of 3 should be used.

Here, I would like to comment on the controversial problem ie phenomenon of creep in the sandwich components.

The magnitude of the creep is dependant upon the characteristics and properties of the material as well as on the loads particularly the permanent load, and the duration of the loading period. It would be advantageous if the permanent load ie dead load, were very small in proportion ot the total load, taken into account when designing the strength of the component. It is common practice to design industrial buildings with a life span of 30 years.

To date there is no information about the negative aspect of creep of the polyurethane or polystyrene within the core in spite of the fact that these types of components have been in use for 15 years. Because of these factors it is permissible to ignore the phenomenon of the creep in the polyurethane or the polystyrene core.

When, however, the structural sandwich component is exposed to high temperature, creep occurs mainly in adhesives between the core and the outside sheets. In this case the creep may be the limiting factor, particularly when designing in tropical countries. It is of course possible to use metal sheets finished in light colours to reduce the negative influence of solar radiation and offer reflective properties. But in such cases it is recommended to consider whether the outside surface of the components will not become dirty too quickly because of the pollution of the air and the molecular structure of the facing materials.

All recommendations referring to the fixing and to the waterproofing factors mentioned in 3.2.2 are the same as for the roofing of the metal components.

In the case of using roof components, with an outside layer of profiled sheet, it is advisable to join the components by lapped joints or interlocked joints. In the case of sandwich components with outside layers of flat metal sheets it is preferable to use joints incorporating special profiles and neoprene seals (gaskets) under compression, namely mechanical joints. The metal sheet on the inner side of the building acts also as the vapour barrier. For that reason joints between sandwich components should be watertight from outside as well as from inside.

3.3 Roof Deck

Typical structure of the roof deck is as follows:

The lowest element of the composite decking which acts also as load bearing element consists of the profiled metal sheets. Second layer is usually a vapour barrier, next there is a thermal insulation and three layers of bitumen felt. The surface of the roof deck is usually finished with mineral chippings. I would like to discuss now all the above mentioned layers of the deck.

The metal sheets in the deck should be laid in such a way that the upper part of the rib is wider than the width of the trough. The metal deck sheets do not usually require the same degree of protection against corrosion as the sheeting. Normally protection by a layer of galvanised zinc is sufficient. Sheets may be fixed to the purlins by shotfire. High class bituminous felt is frequently used as a vapour barrier. This felt should be reinforced with inorganic fibres as for example glass fibre, in order to minimise degradation by sun radiation. To fix vapour barrier to the metal sheets there are used various kinds of adhesives. Sometimes in the case of bigger slope of the roof special treatment of the surface is required to obtain better adhesion.

When polyurethane, extruded polystyrene or other closed cell materials are used as a thermal insulation the vapour barrier is not usually necessary. To protect the roof deck against the excessive solar radiation the outside layer of bitumen felt should be white mineral faced or white stone chppings should be applied on site. Generally decking should be used for roofs with low pitches (less than 10°). When the pitch is too low and the deflections are excessive there is a possibility of water accumulating on the roof. Roofs usually leak in those areas where ponding occurs. Therefore

it is most important to define a minimum slope in every case, dependant on other critical factors.

In my view the minimum slope $\frac{1}{60}$ according to new British Code of Practice is probably sufficient (according to old BCP minimum slope $\frac{1}{120}$ was perhaps too low). According to the new Polish standards the minimum slope is $\frac{1}{10}$ and I think it is excessive, because of the possibility of bitumen felt slipping off the metal sheets.

Taking into account the more adverse weather conditions in Poland I suggest that in our country the roof decks should have the minimum slope of $\frac{3}{100}$ or $\frac{4}{100}$.

Because of the possibility of damage to the bitumen felt, the deflections of the metal sheets cannot be too excessive. So in roofing deck the permissible deflections of metal decking should be more limited than in the sheeting roof. I think maximum deflection $\frac{1}{200} \div \frac{1}{250}$ commonly used in Great Britain is satisfactory.

4 WALL CLADDING

A few years ago many cladding walls were assembled using separate layers. In this type of construction weather conditions affect greatly the speed of assembly, even in moderate wind conditions. In such conditions three-part systems (lining, thermal insulation, sheeting) are difficult to assemble.

For that reason sandwich panels were developed with outside layers formed from metal sheets and inside core consisting of foamed polyurethane. In these types of components the external metal sheet is frequently profiled and the internal sheet is flat.

The junctions between these types of components are usually lapped joints, and are formed in the same way as in profiled metal sheets of cladding composed of separate layers.

These types of cladding create continuous elevations and require special flashings on the corners of the buildings. For that reason there are no difficulties with tolerances. But it is necessary to stress that in these types of cladding there are always difficulties in forming openings for windows, doors, ducts etc. The flashings around such openings should be very carefully detailed to avoid water penetration and sympathetic to the elevational treatment.

Lately some designers use sandwich components with an outside layer as well as an inside layer composed of flat metal sheets using as a core polyurethane or an extruded polystyrene slab bonded to the metal sheets with special adhesives.

Connections between these components should be designed using the joints incorporating specially profiled rails and neoprene compression seals (gaskets). For this type of cladding it is necessary to design a range of various types of components with typical windows, doors, etc.

In my view the modern wall components should have the following properties:

- Components should be capable of being produced individually, as well as in the industrial way (continuous line).
- Cheap
- Capable of having openings formed during design as well as during use.
- Clean inside and outside
- Capable of being changed for another type.

One of the most important principles of designing a cladding system is the selection of the sizes of components.

The views on this subject are divided.

One group of engineers assert that small sized wall cladding components allow an easier manual assembly. Other groups assert that the wall components should be as big as means of transport allows and should be assembled by using light hoisting equipment. The future answer to this problem will depend on the cost of production of components and the assumed method of production. But already it is possible to assert that components produced from the steel sheets by the method of press-breaking and pressing, from the production point of view should be relatively small (longer side maximum 3 m). Production line components should be as long as possible from and transport and strength point of view (the longer side equal to the height of the building). The sizes of components should be related to the functional requirements of internal rooms of the building.

For example, in multistorey buildings like hospitals, schools, offices, the height of external cladding components should be related to the storey heights which could or could not include floor zones.

A very good example of these components I have found in Oxford Method for hospital buildings. In this method the height of wall components was such as to fill up the space between the floor and ceiling. The space of the floor zone, equal depth of floor structure, was filled up by other components. In this way the designer arrived at a very interesting elevation. I have met also, in Milton Keynes Corporation, a very interesting aspect of the design of wall claddings. The new type of cladding for industrial buildings is designed using various sandwich components, lately with vertical components spanning the total height of the building.

This approach is particularly interesting because of simple and quick assembly. In my view these types of components should be common to buildings in which there is compatibility between thickness of the core with regard to strength of the component and thickness in regard to thermal conductivity.

Because of the possibility of the damage to the sophisticated wall claddings it is recommended that the design includes the pavements around the building to avoid the walls being damaged by lorries and trucks.

Also some form of protection inside the building is very desirable. Deflections for the profiled sheets used as an outside layer of the three layer cladding should be no more than $\frac{1}{100}$ of the span. Deflections for the sandwich components should be no more than $\frac{1}{240}$ of the span.

Other applications as indicated in 3.2.2.

5 INFLUENCE OF WALL CLADDING AND ROOFING ON THE STRUCTURE OF THE BUILDING

It has long been recognised that steel sheeting makes a significant contribution to the stiffness of steel framed structures.

So it is possible to consider the roof as a stressed skin diaphragm may well drastically reduce sway deflections and in the pitched roof buildings it may additionally control the spread. The action of the roof sheeting in a building is to behave like the web of a deep plate girder spanning from end gable to end gable. It is therefore necessary that the end gables should be rigid.

In order the diaphragm action can be fully taken into account in design, the following conditions must be fulfilled:

- Each end gable of building must be cross-braces or sheeted so that diaphragm forces in the roof sheeting may be taken down to the foundation.
- The sheeting must be directly fastened to the purlins and sheeting rails and side laps of adjacent sheets must be firmly stitched. For fixing, it is possible to use self-taping screws, bolts and fixed pins. Hookbolts or other fasteners which transmit shear forces by friction are not suitable for stressed skin design.
- The purlin-rafter connections must be capable of transmitting the sheeting forces to the rafters.
- The sheeting and fasteners must be regarded as structural members.

In elastic design, the stiffening effect of steel sheeting depends on flexibility of a panel of roof sheeting in shear, relative to the flexibility of a frame.

The panel flexibility due to sheet deformation is the sum of the following flexibilities:

- flexibility due to sheet deformation
- flexibility due to sheet fasteners
- flexibility due to purlin/rafter connections

If proportion shear flexibility of the panel to the frame flexibility is small the sheeting has considerable effect; if it is large the sheeting has little effect.

The sheeting in buildings may also be considered as helping to resist the load from light overhead cranes.

The effect of the sheeting should not be taken into account in the design of buildings in which length exceeds 2.5 times the width.

It is advisable to consider carefully the suitability of designing stressed skins. In some cases large quantities of additional connections and fasteners may eliminate the expected advantages. But in many cases the results are advantageous.

In conclusion I wish to express my grateful thanks to the British Steel Corporation, the British Council as well as the Oxford Regional Hospital Board and Milton Keynes Development Corporation for the kindness and assistance given to me in my work.

Y. Gagnon 5. IV. 1973.