# ACTIVITIES OF DUTCH CIVIL ENGINEERS ABROAD

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## INTRODUCTION

Civil Engineers in Holland must, in the first place, cope with the manifold hydraulic engineering problems presented by the particular conditions of their low-lying country, covering the delta area of a number of major rivers. Coastal engineering (protection against the seas) and agricultural engineering (reclamation and drainage) were among the first activities of our ancestors, to which were soon added the solving of the problem of foundation difficulties in the soft subsoils. Then came the many problems concerning transportation in a densely-populated delta-country, in which several natural traffic arteries pass and cross: rivers, ports and harbours, but also canals, roads, railways and bridges have to be improved, constructed, extended and maintained. More recently airports have been added to the programme of "alluvial" construction in the typically Dutch environments.

In spite of these varied indigenous activities, many Dutch engineers have long been attracted by the wider scope and scale of work in foreign countries. In the East Indies they acquired and developed the techniques of tropical engineering, such as irrigation, and another dimension was added to their relatively flat field of work when steep mountain roads and railways had to have tunnels, and high dams in rivers were needed for the storage of irrigation water and the utilization of hydro-power.

Many Dutch civil engineers have in the past chosen a career in this area, and later on in the West Indies as well, playing their role in the opening up and developing of a part of the tropics, while at the same time enjoying

the privilege of working in challenging natural conditions. In the late 1930's about 200 Dutch civil engineers were working in the East Indies. But there were also Dutch engineers in other parts of the world; contractors from Holland built harbours and ports on all five continents. Dredgers from Holland can be seen working all over the globe in major estuaries, rivers, harbour entrances and port basins. Moreover, Dutch contractors participate in the building of dams and rivers; they construct roads, railways and large buildings; and in many countries they have offices and subsidiary companies.

Before the Second World War, the Delft Hydraulics Laboratory started to make investigations and model studies of foreign ports for Governments and contractors. Since the war these "foreign" studies, although they are done within the Netherlands, have been increasing in number, and almost one out of every six models or studies is now devoted to a problem of a foreign country. This scientific work often means that engineers from the Laboratory go abroad to collect the data required for the model, or for a field investigation preliminary to the model study.

Since the foundation of the Delft Technological University Dutch experts have worked in isolation in far-away countries as advisers and consultants. Some names may be mentioned here: early in this century KRAUS and VAN MOURIK BROEKMAN worked in South America; later on, HOMAN VAN DER HEIDE did important work in Thailand, BOURDREZ in China and CANTER CREMERS in Egypt. There were many others, and already in the period between the World Wars there was a consulting engineers' office specializing in civil engineering works abroad: NIJHOFF. They all continued along the path already set by the seventeenth-century poldermakers who advised foreign governments on the possibilities of reclamation, but now the scope of their work was much greater and they took with them the various Dutch skills and sciences adapted to foreign conditions. Dutch consulting engineers and experts have greatly increased their activities abroad in the postwar years, and are currently working in some 40 countries on all continents.

Finally, many Delft civil engineers have temporarily or permanently emigrated to foreign countries where they have joined either public works authorities or large engineering firms. In Australia, Canada, New Zealand, South Africa and the U.S.A. there are large numbers of Delft civil engineers. Some indeed, may have changed their nationality, but not

their identity as graduates from Delft. One out of every five or six Delft civil engineers is at present living abroad, or based in a foreign country. Even though in recent years hardly any Dutch engineers have been working in Indonesia, their activities have greatly increased in many other foreign countries. Contractors, consultants and experts are all expanding their work and scope of work abroad. Many institutions, laboratories and other civil engineering bodies based in Holland are carrying out studies and investigations for clients abroad.

What can have been the origin and the reason of all these "foreign" activities? And what is the cause of the recent increase?

Before attempting to answer these questions, a summary must first be made of the above-indicated activities to facilitate the discovery of a possible trend and an explanation of the postwar increase. Such a summary, of course, can by no means be a complete and comprehensive list of all works carried out by, or involving the presence of, Dutch civil engineers abroad [1], but it will at least illustrate the extent and versatility of their activities.

## THE EAST AND WEST INDIES

The development of a country's economy, as we now see it, should be both in the social and in the technological fields. Social development includes the construction of houses, schools, hospitals, towns, roads and public utilities. Although the technological development is already being approached in this phase, a certain infrastructure is required before the economy can get "off the ground" and becomes self-supporting. This will cover the provision of possibilities of transport and means of communication, such as roads, railways, waterways, bridges, ports and airfields. Then comes the technological development with industries and their laboratories, and trade, urbanization, and traffic will increase.

In many cases of a developing country, agriculture must be greatly stimulated to support the nation's economy, to raise surplus funds and profits for the financing of the development work, and to increase the

[1] Much information has been derived from the memorial book: "50 Jaar Afdeling Bouw- & Waterbouwkunde van het Koninklijk Instituut van Ingenieurs 1906–1956".

income of a great part of the population. Agricultural engineering is, therefore, an important component of the development; water management, erosion control, flood control, drainage, irrigation and reclamation are the subjects in which the civil engineer can display his skills and sciences, together with his colleague, the agricultural engineer.

In the former Dutch East Indies, the period between the World Wars showed the same pattern of development. From the following summary, however, one must not gain the impression that all this has been the work of Dutch engineers. On the contrary: Indonesian and Chinese engineers and technicians played an increasing role in the development. The Technological University of Bandung was opened in 1920, and its many graduates assisted, collaborated with, and finally took over from their Dutch predecessors and contemporaries.

The planning of the work was undertaken by Government departments, which at first also carried out the actual construction. Later on, the execution of the works was increasingly done by contractors, and a number of Dutch contracting firms was based in Indonesia, together with local firms.

*Roads* were constructed and developed with the advent of the motor car. Not only was the road network considerably increased in length, but the quality of the surfacing was also improved. Tarred roads, asphalt roads in various compositions, and even roads with a rubber component were tested and constructed. New bridges were made of steel and concrete to supplement the more conventional materials, such as timber and bamboo, of which many economical, elaborate and strong structures were made.

*Railways* were constructed on Java, Madura and Sumatra, up to a total pre-war length of 4,500 miles. A limited number of lines has electric traction, and mountain lines with rack railways were occasionally constructed.

*Ports* have always been very important in the archipelagoes of the East and West Indies. The harbours of Tandjong Priok, Semarang, Surabaya, Belawan and Makassar in the East, and Curaçao and Aruba in the West, were developed into international ports with a considerable traffic handled along caisson type quays. River ports like Palembang, Djambi, Bandjermasin and Pontianak, and island ports in the bays of Sabang and Ambon, were all equipped to receive ocean-going ships alongside concrete or

timber jetties on steel screw-pile foundations. Access to the ports was improved by dredging and by constructing breakwaters.

*Waterways* consisted mainly of rivers, for which before the War only little improvement was justified. A few canals were constructed with appurtenant locks, and dikes along the main rivers prevented floods where these created a danger.

*Airfields* were constructed in many places on the principal islands, to be served by the fairly dense network of inter-insular airlines.

*Buildings* like offices, sheds, stations, hospitals, schools and houses steadily developed from simple single-story wooden and bamboo structures into stone and concrete buildings with a new style, based on tropical requirements and the structural possibilities of the new materials, together with European influences. Systematic town-planning was started shortly before the War, with town extensions, and after the War the new satellite town of Kebajoran near Djakarta was planned and built.

*Public utilities* and amenities came along with the general development and the expanding urbanization. Water supply, sewage installations and power for the main centres were provided, taking into account the special requirements of tropical communities. A separate Government department was established as early as 1917 for the study and design of hydropower stations, and before the War two dozen major hydro-plants were in operation, together with a few hundred smaller stations which served mainly the demands of plantations.

*Agricultural engineering*, as already pointed out, has been important in the East Indies and more recently also in Surinam. Irrigation in the East Indies already dates from a century ago. In the present century, many large projects in the plains of Java and the other islands were studied, designed and executed. Here, the engineer could display his techniques of planning, probability and statistics, hydraulics and construction, along with the activities of his agricultural colleagues. A Hydraulics Laboratory was established in Semarang where new designs for sluices, intakes, stilling basins and weirs were tested and developed.

A large number of major projects, each serving areas of between 50,000 and 175,000 acres, was completed before 1941: six in West Java, two in Central Java, three in East Java, one in South Sumatra, and two in Celebes. Half a dozen large storage basins were constructed to provide for dry-season irrigation, and many smaller reservoirs served the require-

ments of short-term storage. A total area of 8,500,000 acres was made suitable for rice cultivation by means of irrigation.
After the War, irrigation projects were made and carried out in Dutch New Guinea and also in Surinam, where reclamation and pumped irrigation stimulated the cultivation of rice. The hydro-potential of New Guinea was investigated, and the multi-purpose Brokopondo Project in Surinam, now under construction, will also serve irrigation apart from its main power aspect.
The advent of the oil industry in the Indies necessitated many civil engineering works: ports, jetties, roads and bridges were constructed in Sumatra and Borneo, and also in Curaçao and Aruba, for the development of oil-fields and for the operation of the large refineries. The ports of the latter islands were extensively improved after World War II, and the international airports in the West Indies were also constructed and expanded.

## DUTCH CONTRACTORS ABROAD

The Dutch dredging contractors were among the first to extend their field of activities to foreign countries.
Together with dredging – which still is a major occupation of Dutch contractors abroad – they took with them their technique of constructing ports, and the Dutch contracting firms now operating in foreign countries, often specialize in harbour works. From this, they developed into contractors for hydraulic structures in general, and dikes, canals, dams, weirs or bridges are now frequently being constructed in foreign countries by Dutch firms, either individually or in partnership with other foreign or local contractors. But the construction of roads, railways and buildings is also undertaken by Netherlands firms abroad.
For many years dredging was mainly a matter of experience, an empirical art and a skill to which the civil engineer could contribute only little with his theory and science. But with the development of dredging equipment and of hydraulics, and with the widening of the contracting field as described above, contracting became an activity for the Delft civil engineer as well. Laboratory experiments and hydraulic computations are required not only for the design but also for the construction of hydraulic works. Large contractors in the Netherlands either have their

own design office or they call in experts and consultants. Turn-key projects which include both design and construction are sometimes undertaken, whilst in other cases alternative designs made by Dutch contractors are carried out by them. There is a certain tendency nowadays to specify fewer details of construction in the tender documents, and to leave these to the contractor. It will be evident that the Delft civil engineer is closely involved in this development.

A geographical grouping of the main works partly or fully built abroad by Dutch contractors in this century, without laying claim to any completeness, shows the following picture. [1]

In *Europe* Dutch contractors or their subsidiary companies built, dredged, or collaborated in the construction of the undermentioned ports, quays, wharves, and other hydraulic and civil engineering constructions:

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| Spain: | Valencia, Las Palmas, La Coruna, Madrid, Cadiz, Sevilla; |
| Portugal | Leixoes, Peniche, Lisbon, Funchal, Figuera da Foz, San Antonio; |
| England | Leith, Shoreham, Fleetwood, Sandown, Morecambe, the Mersey river, Horsey, Maryport, Middlesborough; |
| Ireland | Cork, Coleraine, Dundalk, Wexford; |
| Germany | Dantzig, Wilhelmshaven and Kieler canal dredging; |
| France | Dunkirk reconstruction, Marseilles, Port de Bouc, Port St. Louis and Atlantic estuaries dredging, Donzère–Mondragon-construction; |
| Belgium | Antwerp and Albert Canal (both dredging); |
| Denmark | Dredging; |
| Sweden | Lulea harbour and Falsterbo canal dredging; |
| Norway | Oslofjord oil installations; |
| Greece | Skaramanga port installations; |
| Malta | Valetta harbour, dockyard and other constructions. |

In *Africa* there have been, and still are, many Dutch contractors actively engaged in port construction and other works:

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| South Africa | Cape Town port and extension, construction of a graving dock, Walvisbay, Durban; |

[1] Much information has been derived from the memorial book: "50 Jaar Afdeling Bouw- & Waterbouwkunde van het Koninklijk Instituut van Ingenieurs 1906–1956".

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| Mozambique | Beira port facilities (alternative design and construction); |
| Congo | Leopoldville jetties, quays and slipway with Belgian contractors; |
| Uganda | Owen Falls Dam with British contractors; |
| Southern Rhodesia | Power-station, brewery, public buildings; |
| Sudan | Port Sudan port installations; |
| Kenya | Mombassa dredging; |
| Egypt | Esna Barrage reconstruction, Idfina Barrage, with British and French contractors, respectively. Port Said and Suez Canal dredging; |
| Libya | Marsa al Bregha Harbour works; |
| Morocco | Ports of Mozagan, Mogador, Casablanca and recently Agadir; |
| Liberia | Monrovia, and public buildings; |
| Guinea | Conakry dredging; |
| Ghana | Accra dredging, public construction; |
| Nigeria | Lagos dredging and reclamation, Port Harcourt approach channel dredging, Escravos breakwater (with British and U.S. contractors), lagoon and creek dredging, pipelines, roads, foundations and buildings. |

In the *Middle East* the activities of Dutch construction companies were often connected with the exploitation and export of the mineral wealth:

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| Turkey | Design, model investigation and construction of a number of ports along the Black Sea and the Mediterranean: Zonguldak, Samsun, Mersin, Bartin. Design of 37 other ports. Participation in construction of airfields; |
| Cyprus | Limassol port construction (participation); |
| Israel | Haifa jetty and dredging (with Israeli firms); |
| Aden | Oil harbour and dredging; |
| Iraq | Musseyib pumping station, Mosul factory, Hillah canal; |
| Kuwait | Dredging; |
| Bahrein | Oil jetties. |

*Asia* and the *Far East* have for a long time, been an area of activity of Dutch contractors:

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| Iran | Nowshar Port (design and construction), roads and railways; |
| Pakistan | Karachi Port (reconstruction East Wharves); |
| India | Bombay oil jetties and naval dockyard, Hooghly river dredging; |
| Thailand | Bangkok approach channel dredging, Sattahip dredging; |
| Phillipines | Oil jetty; |
| China | Shanghai, Chefoo, Macao, Amoy, and, uncompleted, Hulutao, Lao Yao and Canton, all ports, port installations and dredging; |
| Hongkong | Quay walls and port installations; |
| Indonesia | Before and shortly after the War, many Dutch contractors participated in the construction of the public works mentioned in the second chapter of this review. In New Guinea, airports, agricultural stations, factories, roads and public buildings were constructed. |

In *Australia* and *New Zealand* the following works were undertaken:

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| Australia | Melbourne, Perth, Albany, Geelong, Kurnell, Newcastle, Freemantle and Sydney, all dredging; Adelaide Pier and wharf; |
| Tasmania | Dredging; |
| New Zealand | Auckland harbour works. |

The activities of Dutch contractors in the American countries have been restricted to *South America*:

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| Brazil | Ilheos dredging works; |
| Colombia | Dredging, and construction of factories and public buildings; |
| Venezuela | Puerto Cabello and Maracaibo port and oil installations and dredging, Rio Chico, Rio Tuy, Las Morachas; |
| Caribbean | Aruba and Curaçao quay walls and oil installations, San Amdrès dredging; |
| Chile | Talcahuano, San Antonio harbour works, Vina del Mar bridge and San Bernardo railway works. |

The above examples of Dutch contracting work abroad show that the contractor from the Netherlands by no means feels restricted in his geographical field of activities. The same is true, however, for many of his international colleagues, and competition is, indeed, still increasing. Here the Dutch are sometimes limited in their possibilities vis-a-vis foreign competitors, if there is a national protection (either of local contractors or of currency), or when conditions of bilateral aid (*e.g.*, tied loans) make it impossible for them to participate in tendering. The Dutch contractors are then at a disadvantage because their own country has so far not adopted the policy of giving such support to its national enterprises.
This means that Dutch contracting firms must increasingly depend on the good quality and low cost of their performance, on their sometimes superior equipment, on their long and varied experience and on application of modern theories and methods. Where the execution of large hydraulic works is becoming a science rather than an inherited skill, the training of the civil engineer, and his scientific tools, become even more important.
The collaboration between contractors and a hydraulics' laboratory in this respect has already been mentioned, and so the activities of the Delft Hydraulics' Laboratory with regard to projects abroad, must now be outlined.

## FOREIGN MODELS IN DELFT

There was a period when model studies for Dutch hydraulic projects were carried out in a foreign laboratory, because there was no such institution in Holland. After September, 1927, however, the many hydraulic aspects of national projects were all studied in the newly-established Delft Hydraulics' Laboratory; and in the following six years all model investigations there were exclusively for projects within the Netherlands.
In 1930, however, one of these models was of a special character, because it was the first to deal with the subject of a harbour entrance along a sandy coast, namely, the Hook of Holland mouth of the Rotterdam Waterway on the North Sea Coast. This study involved the use of a movable-bed model, in which grains of pumice sand were utilized to simulate the littoral sand-drift in nature, and the movement, deposition and scour of sediments under influence of waves and currents.

This model was the forerunner of a large number of similar movable-bed models and studies of harbour entrances along sandy coasts and a great many of these were along foreign coasts.
The first of these was a study of *Zeebrugge Harbour* in *Belgium* which was started in 1933, and almost simultaneously a model-study of the new harbour entrance to the *Port of Abidjan* on the *Ivory Coast* (West Africa). Both studies were made on behalf of the respective Governments.
Still before the War, two models were made for the *Port of Leith (Great Britain)*, but this time the study was made for a Dutch contractor. These models served to investigate the penetration of waves and the possibilities of reducing the agitation of the water surface along quays and in harbour basins.
After the War a multitude of foreign models were made in the Delft Laboratory, and later also in the De Voorst open-air laboratory: nearly 100 models and investigations out of the almost 600 postwar assignments of Delft. Needless to say, until 1960 all these studies were carried out under the supervision of Professor THIJSSE, who greatly stimulated this "foreign" work, not least because it broadens the outlook of the Delft civil engineer.
To continue the sub-division in subjects, a few more of the foreign sandy-coast models and studies may be mentioned. The possibility of constructing a port at *Ada* in *Ghana* on the Volta River mouth was extensively studied and finally proved. The access to the port of *Lagos* in *Nigeria* was studied almost simultaneously; both models had a bed of pumice sand and were operated with waves and tides. In Lagos, the problem of erosion down-drift from the harbour moles, and deposition and bypassing from up-drift, were studied, and remedies were indicated. Later on, a still larger model of Lagos Entrance, together with the lagoons and port areas, was constructed in De Voorst, with a bed of sand. This latter model is, indeed, a semi-permanent one, in which successive extensions and improvements to the port are studied.
A study of the *Maracaibo Bar* in *Venezuela* was made in connection with shoaling and dredging problems. A similar study was made of the mouth of the *Bergrivier* in *Southwest Africa*, and later on of the *Bonny Bar* in *Nigeria*, where the access to the Bonny oil terminal and to the wharves of Port Harcourt had to be deepened. These studies necessitated site visits and theoretical investigations and computations based on data from the field.

A project for a harbour at *Assab* in *Ethiopia* was studied in miniature. A large model of the *Thyboron Channel* in *Denmark* had a bed of ground bakelite; the problems of coastal erosion and scouring channels were studied, and the recommended solution with moles included the determination of the best alignment of these moles.

The alignment of the new *Escravos* breakwaters in *Nigeria* has been extensively studied in a sandy-bed model. Additional tests on this project examined the stability of the rubble-mound breakwater, possible alternative constructions, and the various stages of execution of the work. An interesting aspect of this series of Escravos tests is that they were respectively commissioned by a Government, by consulting engineers, and by contractors.

The lay-out of the most favourable position of a new channel in *Albatross Bay (Australia)* has been studied in a model with a sandy bed. Studies were also made of *Beyrut Harbour (Lebanon)* and of *Marsa al Bregha (Libya)*. Another model investigation was for the proposed port at Suru near *Bandar Abbas (Iran)*.

Investigations into the penetration of waves in harbour basins, already mentioned in the Leith model, have also been made since the war for the following foreign ports:

Zonguldak in Turkey
Samsun in Turkey
Mersin in Turkey
Bartin in Turkey
Bandirma in Turkey
Latakia in Syria
Tartons in Syria
Midye in Turkey
Canakkale in Turkey
Hanstholm in Denmark,

and for a number of other, mainly Turkish, ports.

The stability of the harbour moles of a number of the above-mentioned ports was also investigated, in addition to which the following profiles of harbour moles were, investigated in the wind and wave-flumes of the Delft Laboratory:

Colombo in Ceylon
Barbados in the Caribbean
Suru in Iran
Ada in Ghana
Escravos in Nigeria
Puerto Cabello in Venezuela.

The currents in the entrance to the harbour of *Curaçao (Caribbean)* were studied in a large model with the use of self-propelled remote-controlled ships. Shoaling of the port of *Workington (Great Britain)* was investigated on site, and so was the siltation in the access to the port of *Bhavnagar*

*(India)*. For the study of the siltation and erosion processes near the port of *Georgetown (British Guiana)* a team of five experts spent more than a year on site; it proved possible to formulate recommendations here without needing a model.
The access to the port of *Bangkok (Thailand)*, which was extensively surveyed and studied on site by a team of eight Dutch specialists, was reproduced in a large model automatically operated with tides and river discharges, whilst the currents resulting from the difference in density of sea and river water were reproduced by actual density-currents in the model.
Foreign rivers also flow in the Delft Laboratory. The flooding of the River *Trent* near *Nottingham (England)* was studied in a model and possible remedies have been indicated. The diversion of the *Stjördal* River *(Norway)*, the effect of bridge-piers in the *Fraser* River *(Canada)*, navigation problems downstream from the proposed *Kainji Dam* in the *Niger (Nigeria)*, and navigation across the *Bajibo Rapids* in the *Niger (Nigeria)* have all been studied in models. In the latter case, self-propelled remote-controlled ships are again being used: from the manoeuvrability of models of the actual river vessels it can be judged to what extent improvement of the rapids is required.
A number of other models are related to hydraulic constructions in various parts of the world.
In the case of a great many of these "foreign" models it is necessary for one or more engineers of the laboratory to pay a site-visit to the area of the prototype. The purpose of this is to investigate the available information, to collect new data by measurements and observations, to familiarize himself with the problems and their environments, and to discuss the questions and possible solutions with the local experts. In many cases a field investigation, with possibly further studies and computations, proves to be a sufficient basis for recommendations as to the solution of the problem.
In this way, many of the civil engineers of the Delft Laboratory regularly go abroad. Another purpose of their frequent trips to foreign countries may be the wish to consult with their colleagues from other laboratories, all members of the International Association for Hydraulic Research, or to attend conferences and conventions.
When it is clear that more will be required than a model study or hydrau-

lic advice because constructions may have to be designed, or when extensive field investigations are required for the basis of computations or recommendations or as a preliminary to a model study, the Delft Hydraulics' Laboratory frequently co-operates with Dutch consulting engineers. But this is only one of the aspects and activities of Dutch consulting engineering in foreign countries: the next chapter will indicate what else they are doing abroad.

## CONSULTANTS TO THE WORLD

Before the Second World War, Dutch consulting engineers confined themselves to work within the Netherlands and its colonies, with one exception: the international consulting civil engineer NIJHOFF's Bureau. The consulting work in Holland itself was further restricted because all major public civil works in the Netherlands are designed and supervised by public authorities, such as the Rijkswaterstaat (State Public Works), municipalities or port authorities.

It was realized during the War, however, that in order to recover from the isolation and damage suffered it would be necessary for Holland to export not only goods but also services and know-how, because only in that way could it play its modest role in the international community once again. Holland had indeed something to offer: their great experience in the design of hydraulic and other civil engineering works, and also of tropical engineering as described in CHAPTER TWO of this review.

This latter point was stressed when it became clear that Dutch engineering activities in Indonesia would be greatly reduced in postwar years, which meant that on the one hand an increased supply of specialist engineers with tropical experience would be available, but that on the other hand this supply might soon end if no new tropical experience was to be obtained by the rising generations.

The problem was how to make the existing know-how available to foreign clients, how to retain a reservoir of expert civil and agricultural engineers with experience abroad, notably in tropical countries, and how to prevent the indiscriminate emigration of these experts to foreign countries with a consequent loss to the Dutch community. This problem was solved in an interesting way.

An independent joint Netherlands consulting engineers' organization was

established to study, to plan and to give advice on matters of public and private engineering in countries abroad. It consists of a permanent staff of experienced engineers in charge of preparatory and co-ordinating activities, who can and will, if required, call in various experts and organizations available in Holland. To this end, the co-operation of Government and other authorities, as well as that of many Dutch public institutions, consulting offices and specialised engineers, has been secured.

By this system of co-operation it has become possible to pool the entire knowledge and experience of experts in Holland, including those in public functions. This system also makes it possible to call on specialists in fields outside the scope of civil engineering experts: specialists on agricultural subjects may be consulted for problems of irrigation or reclamation; expert advice on matters of organization may be required for problems of transport by water, rail road or air. This co-operation on a national scale makes it possible to tackle extensive and complicated problems beyond the capacity and scope of normal consulting offices and engineering firms. However, in many cases the existing, and in the past ten years greatly expanded, private consulting engineers' offices carry out the required studies and designs and supervise the execution of the works on behalf of the central joint organization, but under its overall responsibility and co-ordination. The co-operation also includes the two large agricultural engineering and land development bureaus in Holland, as well as a bureau of airport consultants.

Normally the phases covered by consulting engineers include the appraisal of the problem, the making of a feasibility project, the preparation of a general design, with estimates and specifications, the drawing up of the tenders and selection of the most acceptable tenderer, and supervision of the construction. The actual construction is left to contractors.

The co-ordination of the Dutch consulting engineering activities has met with an encouraging response not only from those concerned in Holland but also from the foreign authorities in charge of development and construction. Here is a summary of the principal studies and projects made by Dutch consulting engineers in the past twelve years:

*Hydro-electric projects*

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| Surinam | Study of the technical and economic feasibility of a large storage reservoir and water-power station. |

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| New Guinea | General study of water-power potentialities. |
| Nigeria | Comprehensive studies, in co-operation with British Consultants, on the feasibility of a multiple-purpose dam in the Niger River near Kainji; preparation of tender documents. |

*Harbour and Port projects*

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| Iran | General study with projects on the development of some southern Persian Gulf ports.<br>Preparation of design and tender documents for the Ports of Bandar Abbas and Bushehr.<br>Investigation into the possibilities of increasing the depth of the approaches to the Port of Bandar Mashur. |
| Pakistan | Study on the reconstruction of the East Wharves at the Port of Karachi.<br>Report, design, and supervision of improvement of five inland ports in East Pakistan. |
| Ceylon | Study of the operation and development of the Port of Colombo and other ports. |
| Thailand | Field investigation and model study of the approach channel to the Port of Bangkok with the object of reducing maintenance dredging costs. |
| Ethiopia | Preliminary project and survey of Port of Assab. |
| Mexico | Report on general programme of the development of all ports in Mexico. |
| Nigeria | Field investigation of possibilities of improvement of access to the Ports of Burutu, Warri and Sapele; model study of recommended Escravos improvements.<br>Preliminary design for improvements to the river Port of Baro. |
| Ghana | Supervision of the construction of a cement clinker handling jetty at Takoradi. |
| Morocco | General investigation into economical and technical possibilities of the developing of some Mediterranean ports. |
| Brazil | Preliminary study on the improvement of approaches to Porto Alegre. |

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| Surinam | Design and supervision of construction of a new port at Paramaribo. |
| British Guiana | Economic and technical study and planning of the reconstruction of the Port of Georgetown. |
| Colombia | Project for the rehabilitation and improvement of the Port of Buenaventura, in co-operation with Colombian consultants. |

*Reclamation, irrigation and drainage projects*

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| Iraq | Project for the Abu Dibbis and Wadi Thartar depressions and supervision of construction of the Razaza dike at Abu Dibbis. |
| | Project on drainage problems in Hilla-Diwaniyah area. |
| | Projects for several pumping stations. |
| Iran | Project of an irrigation scheme on the Karkheh River in Khuzistan. |
| Syria | Multiple-purpose scheme for the Ghab Valley, including reclamation, irrigation, reservoirs, power, fisheries, and planning of towns, villages, farms and roads. |
| | Investigations on irrigation, drainage and reclamation of soils in the Euphrates Project Area. |
| Egypt | Study of the possibilities to protect Philae monuments by construction of a dike. |
| | Drainage Project by application of tile-drains in the Nile Delta. |
| Ethiopia | Irrigation project for a sugar estate at Wonji. |
| Nyassaland | Survey and exploratory investigation for the reclamation and utilization of the Elephant Marsh. |
| Rhodesia | Feasibility study for reclamation of the Kafue Flats and supervision of development of a pilot polder. |
| Congo | Irrigation project for a sugar estate. |
| Ghana | Report on irrigation and cultivation of the Angaw Lagoon basin. Project for storm drainage of Accra. |
| Guinea | Drainage and sanitation project for an area near the Rio Nunez. |
| India | Study and supervision of a pilot polder in Saurahstra. |
| | Preliminary report, design and supervision of drainage |

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| | and reclamation of the Northern Salt Lake near Calcutta. |
| | General advice and assistance for investigation into the possibility of reclaiming the Sunderbans area southeast of Calcutta. |
| Japan | Report on the impoldering project of Hachiro Gata Lake. |
| Korea | Project for tidal land reclamation in the southern and western coastal areas. |
| New Zealand | Report on the Waimea Estuary Reclamation Project. |
| United States | Report on the feasibility of reclaiming the Hackensack Meadows in New Jersey. |
| Cuba | Study and project for master-plan for impoldering of the Zapata swamps. |
| Puerto Rico | Project for a pilot polder in the former Guánica Lake. |
| Argentina | Survey and investigation for a pilot polder in the Paraná Delta. |
| Greece | Study and supervision of reclamation of a lagoon area with pilot polder near Missolonghi. |

*River investigations*

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| Nigeria | General survey, study and investigation of the Niger and Benue Rivers with the object of determining how the navigation conditions can be most effectively improved. |
| | General study of the hydrological regime and the navigability of the Niger Delta. |
| | Preliminary study of possibilities to improve the Cross River. |
| | General advice to the Inland Waterways Department as consultants for hydrological matters. |
| | Design for and supervision of clearing the Bajibo Rapids to improve the navigability; continued study with a hydraulic model. |
| Ghana | Study, design and supervision of projects to improve the drainage capacity of the Odaw and Nima Rivers and the Korle Lagoon to prevent annual flooding of parts of Accra. |
| Brazil | Study of the lower parts of Rivers Paranapanema-Tibagí |

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| | and Ivinheima-Brilhante for the improvement of navigability. |
| Iraq | Study of the Tigris between Mosul and Baghdad to determine the possibility of improving the navigability. |
| Pakistan | General advice as Consultants to the East Pakistan Inland Water Transport Authority. |
| | Comprehensive survey with recommendations for the improvement of the navigable waterways of East Pakistan. |

*Roads, railways and transport projects*

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| Turkey | Preliminary study of traffic problems in Istanbul. |
| | Study of the unification and renewal of tracks and bridges of the State Railway. |
| Iraq | Project on construction of the Baiji-Quaiyara road and supervision of execution of the Kerbela-Najef and Najef-Abu Sukhair roads. |
| Ruanda | Supervision of the construction of roads. |
| Niger Republic | Study of the transport facilities with the object of improving the transport routes to the Atlantic Ocean in co-operation with French Consultants. |
| Argentina | Study of the railway, ports and navigation sections of an overall transportation study. |

*Bridges*

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| Iraq | Project for and supervision of construction of a highway bridge across the Tigris at Mosul. |
| Nigeria | Project for and supervision of construction of a highway bridge across the Niger at Onitsha. |
| Ghana | Study, design and specifications for a highway bridge across the Volta near Tefle. |
| | Project and supervision of construction of a road bridge across the Korle Lagoon near Accra. |
| | Project and supervision of construction of two railway bridges. |
| Canada | Project and supervision of construction, in co-operation with Canadian Consultants, of a highway bridge across the Fraser River near Vancouver. |

*Industrial projects*

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| Brazil | Study of coal mining and related industrial problems. |
| Surinam | Study on problems of bauxite mining. |
| Curaçao | Study of possibilities of extending the saltwater distillation plant; design, tendering and supervision of construction of the additional plant. |

Though the majority of these projects refer to the typical hydraulic and transportation problems in which the Dutch have been specializing in their own country, it is evident that many other studies and investigations are also being undertaken, mostly concerning tropical engineering.
Economic aspects cannot be neglected in any engineering project, and sometimes the economic angle is predominant. For these and other cases co-operation has been established with the Netherlands Economic Institute of Rotterdam.
Co-operation with foreign consultants also occurs, as can be seen from the above summary. This is usually an ad-hoc collaboration for a specific project, either at the special request of a client or because a project may seem to be too comprehensive to be undertaken by any single engineering consultant. On the other hand, the composition of the joint organization is exceptional in that almost all branches and aspects of development projects are combined within one organization.
It is difficult to estimate how many Dutch engineers are normally overseas in connection with consulting engineering work, but at the time of writing this review there are some 70 consulting engineers' technicians abroad, only a part of whom are civil engineers, at work on some 15 major projects. But almost all assignments necessitate a shorter or longer visit of a civil engineering specialist to the site for discussions with the Client, for preliminary studies, and for data collection and field surveys. On the other hand, much of the design work and the writing of reports is being done in Holland.
The Head Office of the above-described joint organization in The Hague is fairly small in itself, but when the offices of the separate co-operating consulting engineers are included, the total number of civil engineers permanently occupying themselves with consulting engineering work for foreign countries will amount to over a hundred.
It must be pointed out here that the joint organization has not got the

monopoly for Dutch consulting engineers' work abroad. It is a voluntary grouping, and separate consultants' bureaux may well operate on their own, and under their own name, in foreign countries. The object is only to promote and extend the activities of Dutch consulting engineers abroad, and in many cases it is a clear advantage to bring these activities under one common denominator. The export of our national skill and know-how, *viz.*, of the designing of large hydraulic projects and constructions, is almost exclusively being done within the national grouping. But a number of consulting civil, geodetical, architectural, and agricultural engineers work abroad under their own name for a variety of reasons.

For instance, in 1961 a civil engineering services company was established, a private company which specializes in the carrying out of all kinds of field investigations required for the design and the construction of civil engineering projects. It also collaborates with the Delft Hydraulics Laboratory, and with a soil mechanics laboratory.

This company has carried out hydrographic surveys and hydrometric observations *a.o.* in Mozambique and in Libya. Major oil companies have in these cases made use of its services.

The future of the Dutch consulting engineer to work abroad is, naturally, dependent on the development and expansion of the engineering know-how and experience in Holland, because in many of the developing countries the science and practice of engineering is steadily progressing. Holland can only continue to offer its technical services for study and design of civil engineering projects when it is an advantage to obtain advice from the Dutch: when they can produce better, cheaper or more advanced projects.

For this reason the progressive introduction of research and science in the work of Rijkswaterstaat (the State Public Works) and the Delft Hydraulics' Laboratory is highly important. Experts from the State can, fortunately, in many cases be made available for short periods to advise on foreign projects. The Delft Hydraulics' Laboratory, and notably Professor THIJSSE and his successor Mr. SCHOEMAKER, has been and still is the mainstay of the Dutch consulting engineer. Many of their assignments have originated from contacts of the Laboratory, and for many projects the advice and co-operation of the management and staff of the Laboratory is indispensable. Many former engineers of the Delft Hydraulics' Laboratory, graduated from the "School of Thijsse", have joined

consulting engineers' organizations, together with engineers from other laboratories and institutions.
The Dutch consulting engineer working abroad is, indeed, in a most fortunate position to have the support of the Laboratory and of the hydraulic services of the Government experts whenever this may be required.

### THE EMIGRATED MAN FROM DELFT

It has already been stated that one out of every five or six Delft civil engineers is based in a foreign country. This may be only temporarily, when he is stationed abroad by a Dutch firm, a contractor or a consultant for a specific project. But a number of Delft civil engineers have left the Netherlands permanently, or at least for long periods, to live in foreign countries where they work for foreign firms or organizations. Or they may have joined an international body such as the United Nations and its specialized agencies such as the Food and Agricultural Organization, the Economic Commission for Africa, or for Asia and the Far East, or the World Bank.
Indeed, in most of these multi-lateral organizations one can find Dutch engineers dealing with hydraulics, ports, rivers, polders and locks for projects that are undertaken on an international basis. The Dutch are there for obvious reasons: international bodies require international staff, well-versed in the aspects of civil engineering abroad.
Many engineers are only temporarily employed by international bodies. Under the programmes for Technical Assistance of the United Nations or of the Netherlands, some ten to twenty civil engineers a year are sent out as individual experts to foreign countries for assignments that may last from a few weeks to a few years.
It is more difficult to analyse the work and the motives of those engineers who have emigrated privately to foreign countries. A number of these have undoubtedly been attracted by the thought that to work and live abroad would be more interesting and remunerative than to follow a career in Holland. Some may have thought that there was no future for them in the over-populated restricted area of the Netherlands, or that a new country might offer better chances to their children. At present, the following numbers of civil engineers live in some of the main emigration countries:

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| Canada | 43 | Australia | 11 | U.S.A. | 47 |
| South Africa | 35 | New Zealand | 12 | | |

As only a few Dutch firms work in these countries, it may safely be assumed that most of these civil engineers have emigrated there.

These men from Delft are welcomed by foreign firms and Governments when they have something to offer and to contribute, resulting from their training at the Delft Technological University or from their own approach to problems.

It is, however, sometimes experienced that a civil engineer just graduated from the Delft University is at a disadvantage in comparison with his foreign colleague, notably because he has but little experience. In the United Kingdom and in Commonwealth countries an engineer does not usually qualify professionally before he has obtained the associate membership of an Institution of Civil Engineers, which is only possible after some years' practical experience. Young engineers who have worked in Holland for a few years after their Delft examination before going abroad have, however, a double advantage: they are considered "fully qualified Delft Engineers", and their market value is increased because they have something more to offer, especially when they have obtained experience in the typically Dutch field of hydraulic engineering.

Many civil engineers have, indeed, first spent a few years in the Delft Hydraulics' Laboratory and thus passed the "School of Thijsse" before going abroad. It is felt that this post-graduate training in hydraulic engineering is a most valuable passport to foreign countries, but at the same time it should be realized that by this emigration many capable engineers are temporarily or permanently lost to the Netherlands, where the local and semi-international possibilities of employment are certainly not exhausted.

## WHY WORK ABROAD?

In the Introduction to this review the question was raised about the origin of and reason for all the "foreign" activities of the Delft civil engineer. The summary of the various types of work undertaken by Dutch engineers abroad makes it possible to deduce a number of reasons. However, first the personal angle must be considered.

Like their ancestors – discoverers and traders of the Asian, African,

American and Australian coasts – many of the present Dutch civil engineers seem to like travelling and working in foreign conditions. There is a fascinating element in working abroad, especially in tropical areas, and this is also generally the case with civil engineering. The scope of work is often wider than in Holland, no matter how large some of the national projects themselves may be; conditions in other countries are more challenging, and work may have to be started "from scratch" instead of conforming to a set pattern as in the Homeland, or participating in only a section in the greater complexity of well-developed projects in Holland; and opportunities to do outstanding work in developing countries are more frequent, whilst the responsibility and also the chances of promotion are usually greater than in the Netherlands.
Being Dutch, the often higher remuneration abroad may also be an incentive, even though this often proves to be only a just compensation for work which is harder and has to be performed under difficult conditions. Finally, the climate in Holland may also be a reason why many Dutch people are only too anxious to travel to warmer countries.
Whatever the reason may be, it has never been very difficult to find a Dutch civil engineer willing to go abroad for a shorter or longer period.

But which opportunities are offered to him, and how can it be explained that there is a continuing demand for Dutch civil engineering activities in foreign countries?
The first and obvious reason lies in the typically Dutch technique of developing low-lying and swampy deltaic areas into safe regions able to support a large population with its agriculture, road, rail and water transport and industries. Apparently these techniques, starting from the skill of the polder-makers and the dredgers, and resulting in modern hydraulics and alluvial civil engineering, are not yet being employed on a sufficiently large scale by other peoples. Of course, the Dutch by no means have a monopoly in this, but by steadily developing their research and science, their hydraulics and tidal computations, the engineers from Holland can still maintain their advantage.
Secondly, there is a great demand nowadays for such development activities as reclamation, waterway engineering, drainage and coastal engineering, now that many young countries are maturing and developing

in a period which has appropriately been proclaimed the Development Decade.

The opportunities to give advice in foreign countries have, too, greatly increased with the advent of air travel. Now in the jet-age it is easy to leave one's desk in Holland for a while to spend a week or so in Asia or Africa, and to return to normal duties with very little interruption.

It may be that the Dutch engineer, coming from a small country, is particularly equipped in other ways for work abroad: he usually has a fair knowledge of several languages, is willing to collaborate with his foreign colleagues, and can adapt himself to new and foreign conditions. Finally, so many Dutch civil engineers may find themselves abroad because "for a very small country like the Netherlands 'abroad' is so very large!"

May the Dutch civil engineer, backed by tradition and by the Delft science and laboratories, continue to work in this very large "abroad" and thereby develop both his host-country and his own skill to the benefit of Dutch civil engineering.