

REPORT

ON

PROCEEDINGS OF 37TH EXECUTIVE COMMITTEE
OF INTERNATIONAL COMMISSION ON LARGE DAMS AND
OF THE RIVER VALLEY PROJECTS IN
AND CZECHOSLOVAKIA

BY

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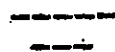
CENTRAL WATER & POWER COMMISSION.

37th EXECUTIVE COMMITTEE MEETING OF
THE INTERNATIONAL COMMISSION ON LARGE DAMS - WARSAW (POLAND)
SEPTEMBER, 1969

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37th EXECUTIVE COMMITTEE MEETING OF
INTERNATIONAL COMMISSION ON LARGE
DAMS - WARSAW (POLAND) FROM 8-10th
SEPTEMBER, 1969

1. INTRODUCTION

The 37th Executive Committee Meeting of International Commission on Large Dams was held at Warsaw (Poland) from 8th to 10th September, 1969 followed by a study tour of works in Poland and Czechoslovakia from 11th to 18th September, 1969.

The Meeting was attended by about 150 delegates representing about 41 Nations. There were some ladies accompanying the delegates. The meetings of the Executive Committees were held at the Palace of Culture and Science Adam Mickiewicz. Polish Committee on Large Dams extended all facilities to delegates for their stay and study tour.

2. PROCEEDINGS OF EXECUTIVE COMMITTEE

The meeting started with a address of welcome from the Chairman of the Polish National Committee followed by general opening remarks by the President ICOLD.

Homage was then paid to the memory of Members of ICOLD who passed away after the last Executive Meeting:

Dr. Claudio Marcello (Past President)

Prof: H.Press German Federal Republic.

Ryotare Takai Japan

N.Shand South Africa.

The presence of Mr. Rutby, Secretary World Power Conference was welcomed.

Having confirmed the minutes of the previous executive Committee, the Agenda items were taken up:-

Cyprus and Netherlands were elected as Members of ICOLD

Mr. N.G.K. Murti was elected as Vice President for the Asian Zone unopposed and he thanked the ICOLD for the honour done to India and through his country to him.

For the Vice Presidentship of the Afro-Australian Zone, a secret ballot was taken for the two candidates Messrs, Emanuel Lertey from Ghana and Mushapha Paris from ~~Madagascar~~. Mr. M. Paris was elected by 26 votes to 13 of Mr. Lertey.

For the Executive meeting of 1971, four countries extended invitations. Yugoslavia, Australia, Venezuela, and Morocco.

Venezuela withdrew its proposal in view of the large number of invitations, hoping that his country's invitation when renewed, would be favoured with more support.

Morocco withdrew its proposal in favour of Yugoslavian invitation.

When put to vote, Yugoslavia got 21 against Australia's 18. Yugoslavian delegation thanked the ICOLD and Australia's responded with the hope that the Executive Meeting of 1972 will be held in Australia. Dubrovnik is the venue of the meeting in Yugoslavia.

3. REPORTS OF COMMITTEES.

3.1 - Financial Report.

Financial statements for 1968 and budget for 1969 were passed. The situation is satisfactory. Due to anticipated heavy expenditure in the Montreal Congress the situation in 1970 may show some deterioration.

3.2 - Committee's reports.

(a) Technical Dictionary: Mr. J. Bellier Chairman

The Swedish proposal to widen the glossary on dams to include all words used in the design, construction and maintenance of dams was discussed and defeated after a vote. The glossary would then limit itself to the words used in the World Register of dams only and not overlap or intrude into the work of revision of the Technical Dictionary on dams.

The Secretary General pointed out that the sale of Technical Dictionary on dams dropped from 100 to 150 per year till 1968 to 19 only in 1969: Probably due to the expectation of a revised edition.

(b) Dr. Nose introduced his report on the Committee on Earthquakes - France gave way to Yugoslavia on this Committee while Italy and USSR changed their nominees on the Committee. This was approved.

(c) Mr. Willm presented a translation of Mr. Bertram's report on General consideration on observation of "Earth and Rockfill dams" and observed that the list of instruments is only a guide and not an exhaustive list of instruments offered by manufacturers all over the world.

(d) The World Register on Large Dams. The Glossary will be limited to the words used in the Register on dams only.

3.3 - Progress Reports.

(a) World Register of Dams.

A proposal was made that the Register should also include information on dams in non-member countries, and that such information should be obtained from Governmental and official sources of the non-member countries on a purely voluntary basis. This proposal was accepted.

Mr. Lermel deplored the inadequate response to the circulars. He summarised that in the 3 years 1966 to 1968 (both inclusive) the number of dams completed were 925 bringing the total for the world from 8590 to 9515. A growth of nearly 10% in 3 years (1966-1968) is indicated. In this period 304 Million Acre Feet of storage was added (i.e.) nearly 100 MAF per year, but it so happens that at times one mighty dam alone can account for a major part of the annual increase. Available information was summarised as that about 900 dams are under construction and an equal number are proposed for construction.

During the 3 year period USA added 370 new dams while Japan added 96, India taking the 3rd place with 43, Canada is close 4th with 42 dams. Australia, Spain, and Norway were bracketted in the 5th place with 32 each; Mexico 31; France 29, South Africa 28.

Of the 925 completed in the 3 years (1966-68) 700 are of earthfill and rockfill type and 225 of concrete and masonry (i.e.) 76% and 24% respectively. In USA where 346 out of 370 are of earthfill (i.e.) 93.5% Japan where only 44 out of 96 are in earth and rockfill (i.e.) 45%. (balance 55% is of concrete) strikes a medium. The position in India resembles that of USA in as much as 38 out of 43 are in Earthfill (i.e.) 90%.

Switzerland has the other extreme of 10 out of 11 in Concrete (90% concrete and 10% Earth rockfill). Spain has 26 out of 33 in Concrete (80% concrete 20% Earth).

In Thailand all the 12 dams completed are Earth Dams and so in Turkey 12 out of 13 are in earth. These and other examples swing the world's %age of Earthdams to a high figure of 76%.

811 out of 925 are under 200 ft. in height (88%) while 96 (10%) are between 200 to 400 ft. in height. Balance 2% are above 400 ft.

In terms of volumes of dams, 78 million cu.yds. of concrete and masonry have been placed in 3 years against 1,189 million cu.yds. of earth and rockfill moved into position (15 times the quantity of concrete). In India 2.9 million cu. yds. of concrete were placed against 22.5 million cu.yds. of earth moved (nearly 8 times concrete volume).

Of the 303 million acre feet, gross storage 204 Million Acre Feet are in Canada. It only shows the advantages possessed by Nations of very large areas with low population density and that too concentrated and localised at some places of equable climate. They can create large lakes without any serious problems of rehabilitation. Canada, some of the African Nations, Siberia in USSR, Brazil are some such countries.

The world's average of gross storage per dam during the period 1966-68 is 0.33 MAF while the Indian average is 0.111 MAF. The record storage per dam goes naturally to Canada at 5 MAF per dam (16 times the world's average in the triennium with the other end of lowest storage being in South Africa 0.004 MAF per dam, followed by Great Britain with 0.0125 MAF per dam and Switzerland with 0.0226 MAF per dam.

Assuming that the Earth Dam volume is nearly 10 times the volume of Concrete dam, the volume of dam per MAF of gross storage would yield the following information for the triennium 1966-68 (both-inclusive). The above ratio is approximate for gravity dams but in the case of arch dams (double curvature and multiple) the corresponding volume of earth dam may be 20 to 40 times depending on the circumstances. Yet a study in the above lines will be of interest and is, therefore, presented. For MAF of gross storage, the world's average in the triennium is 6.5 M.Cu.yds. of Earth to be moved into position. While the India data is 10.8 M.Cu.Yds. The minimum is in Canada where only 1.23 M.Cu.Yds. are needed for one Million Acre Feet, while U.S.A. moves 17.5 M.Cu.Yds. per MAF of gross storage. The highest extremes per MAF gross storage are obtained in 171 M.Cu.Yds. in Switzerland 75.3 M.Cu.Yds. in Great Britain and 52.7 M.Cu.Yds. in South Africa. If Canada is excluded the World's average comes to 17.13 M.Cu.Yds. per MAF of gross storage somewhat similar to that of U.S.A.

Depending on the economy of the country, much larger volumes of dam per MAF of gross storage were justified that what was obtained in India in the same triennium. In the future Indian dams, a rise over 6.5 M.Cu.Yds. per MAF need not be looked at in disfavour.

Secondly the World Register records only 475 dams in India against a world's total of 9515 dams. There are many dams in Andhra Pradesh, Madras, Mysore and Maharashtra which could claim being called a large dam as per definition. It is, deplored that the information is not forthcoming readily despite the topic being pursued by the Central Board of Irrigation and Power.

This led to an examination of the number of dams in a country as in 1965 per 10,000 sq.KM of the nation and gross storage per million population. The 1965 register showed 8590 dams with the total area of the nations listed at 280 Million Sq.K.M. and a gross storage of (2,154)¹million Cu.Meters or 1723 MAF for a population of (2050) millions in these nations. The world average worked out to 3.2 dams per 10,000 Sq. KM and 105 M.Cu.Meters or 0.841 million Acre ft. of gross storage per million population. Correspondingly, Indian figures are 1.15 dams per 10,000 sq.KM and 178.1 M.Cu.M or (0.142) Acre Feet per million population.

It is natural to expect prosperous nations of small areas to have a high number of dams per 10,000 sq.KM. Japan with 49.20 followed by Switzerland with 22.15 and Great Britain with 17.49 - USA figures is 3.28. Should we not aim at an average of a dam per every 1000 Sq. mile (i.e.) 10 dams per 10,000 sq. KM. It is worth an examination.

Gross storages are not so indicative of the Nation's effort as live storages are, per million population. In the absence of this information gross storages had to be adopted. Naturally, Rhodesia with the great Kariba Lake takes the pride of place with 39,250^mCu.M. or 3.14 MAF per million population. While Canada trails second with 10,168^mCu.M per million population, U.S.S.R. and USA have 3410^mCu.M (2.73 MAF) and 2840^mCu.M. (2.27)MAF) per million population.

These figures tend to alter according to the increase in population to a given gross storage in any period. Whether a target of 1000 M. Cu.M. per million population or even one million acre feet per million population should be aimed at in India (i.e.) 100 Cu.Ft. per day per capita is debatable but a similar scale for live storage would be a useful guide to enable a nation know what to aim at.

(b) Committee on Accidents and Failures due to foundation causes:

	<u>Rock and Earthfill</u>	<u>Gravity Buttress</u>	<u>Arch</u>	<u>Total</u>
Movements in foundation	27	6	2	35
Erosion in foundation	38	13	4	55
Other causes	15	9	1	25
	<u>80</u>	<u>28</u>	<u>7</u>	<u>115</u>
%	70	24	6	100

In the absence of a countrywise statement it was not able to compare Indian figures with those of world's average; maximum and minimum for the 3 categories of dams. It only emphasizes the importance of foundation studies of earthdam which seem to be taken for granted as easy.

(c) Committee on failures of dams for causes other than foundations:

The Committee was authorised to collect and compile information regarding criteria and current practices in design and analysis of spillways. This approach stems from a belief that inadequate spillway is the greatest contributory factor to accidents of failures.

In a presentation of the collected data, the Committee categorised it as under :

- Failure Type (1) Major failure resulting in complete abandonment of the dam.
- Failure Type (2) Failure when it occurred may have been severe but the damage was repaired and dam restored back into use.
- Accident Type (1) An accident to dam already in use which was prevented from becoming a failure by immediate remedial measures.
- Accident Type (2) An accident to a dam at the initial filling which was prevented from becoming a failure by immediate remedial measures.
- Accident Type (3) An accident during construction which was detected before filling of water and remedied in time, to enable thereafter water being stored safely.

Of the 344 cases listed 33 are from India concerning 27 dams. Studied in terms of % of various categories, the Indian % are low compared to the world % is F1, A2, and A3 categories and the same in F2, but in excess in A1 (i.e.). This naturally happens when we have a large number of old dams designed according to the knowledge and criteria of the times of construction but not now considered inadequate (World average of A1 is 23.0%, while India's is 52%.

Expressed as a % of dams completed or under construction till 1968, failures and accidents, world %s are 1.8 and 1.4 respectively against 1.9% and 3.2% respectively of India. In other words we have more accidents particularly of A1 type (i.e.) old reservoirs giving troubles. Failure type (1) (i.e.) completely abandoned dams are 0.7% in the world. In India it is only .15% which is really encouraging.

Examining the accidents and failures with respect to the heights of dams, 52% of total accidents and failures in India are in the height region 15 to 30 meters (i.e.) 50 ft. to 100 ft. 21% in the height region 30 to 45 meters (i.e.) 100 to 150 ft. height and 12% in height region 45 to 60 meters (i.e.) 150 to 200 ft. In other words, the same care is not bestowed on dams of lower heights than on those of higher heights, meaning thereby that a sort of complacency sets in,

in the design or in construction of numerous dams of low heights. We should not take things for granted even in low dams is the conclusion from this study.

(d) Committee on observation on Dams and Models.

Reports on various aspects are under preparation and none presented, nor any new methods indicated.

(e) Committee on Earthquakes.

This committee has just been formed and issued questionnaire regarding seismic design procedures obtained in various countries. Other aspects to be gone into are :

(i) whether impounding of water in large reservoirs cause tremors and trigger off earthquakes,

(ii) cost increase due to seismic designs;

(iii) acceleration response in the vicinity of vibration mode, natural frequencies and damping ratios.

(f) Committee on Concrete

Two documents are under preparation.

(i) Recommendations on pozzolanas and other substitutes of cements in concrete for large dams;

(ii) Recommendations on accelerators and retarders for use in concrete of large dams.

Italian Committee reported that they are using extensively pozzolanas, Ferric cements, Ferric pozzolana cements and blast furnace slag cement. They are able to obtain a quality control of 15% coefficient of variation on Balga Bissina dam, 10% at Speccary and 8.2% at Talvaccia.

They use no slump concrete and vibrate upto 60 seconds. Upto 90% of mix water is substituted by ice to reduce dangers of refreezing.

That they had jointless massive hydraulic structures in 1921-26 in Italy is in keeping with similar tradition obtained in India till 1930.

While improvement in Earth moving and hauling equipment, foundation problems have contributed to a greater number of earth and rockfill dams, relatively less improvement is recorded in concrete making and handling techniques and therefore a symposium on Rapid Construction of Concrete Dams is being held in San Francisco of U.C.O.L.D in March, 1970.

(g) Committee on Relations with other International bodies.

Closer association with allied organizations such as World Power Conference, ICID, IAEA, IS ON&FE, IS for RM and IAEA, and less close association with other bodies was the line of thinking.

4. GENERAL REVIEW.

4.1 - Tenth Congress.

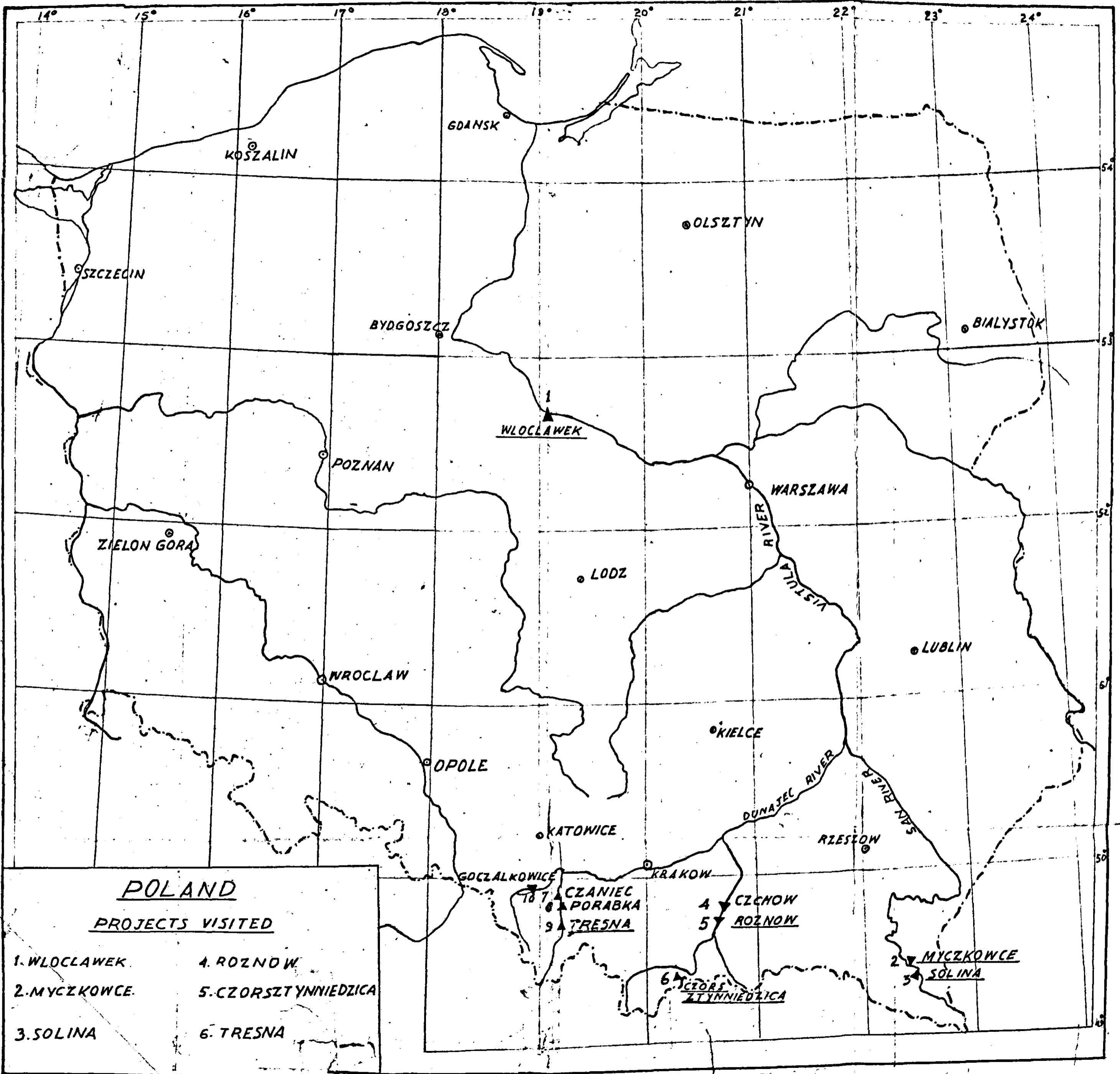
Large contingent is expected from USA and some restriction on accompanying members of the family was sought to be voluntarily exercised. Tour I is preferred by too many. They are expecting 900 delegates and with accompanying family members the number attending may be 1800. Some 450 are expected to take the study tours. This will give an idea of the popularity of these meetings and if India's present is to be felt the delegation 2 or 3 strong is much too meagre and ineffective.

For 1970 Congress, 195 papers have been received against all the 4 questions in comparison with () papers of 1967 Congress. By virtue of having built 345 dams since 1938, India is entitled to contribute 14 papers against which only 6 papers were submitted. While quality is the essence of the papers, quantity cannot be ignored. If India has to offer consultancy services, it can be not through advertisements but through the number of papers submitted before ICOLD Congress and their quality. More Engineers should be encouraged both to present papers (General papers and communications) and also be allowed to participate in the Congress.

4.2 - A lively discussion on the Norwegian proposal to permit the reproduction of a document presented to the Congress (including a translation) earlier than 6 months after the actual Congress, after making a reference in full to the presentation in the Congress. In the case of authors whose mother tongue is neither English or French, it was allowed that they may publish their papers in their own language soon after the Congress. Those with mother tongue of English and French felt discriminated but an amendment can be tabled 3 months before the next Executive Meeting.

4.3 - Subscriptions are according to 8 groups depending on the scale of assessment adopted by U.N. during 196-70. It is surprising that India falls in Group 5, (% 1.26 to 3.00%) when more affluent countries like Sweden, Switzerland fall in a lower group 4 (0.76 to 1.25%).

4.4 - The meeting ended with usual courtesies to the hosting nations.



POLAND

PROJECTS VISITED

- | | |
|---------------|----------------------|
| 1. WLOCLAWEK. | 4. ROZNOW. |
| 2. MYCZKOWCE. | 5. CZORSZTYNNIEDZICA |
| 3. SOLINA | 6. TRESNA |

5. VISIT TO WORKS.

5.1 - In Poland.

General - Poland covers a total area of 312520 sq. Km. with a population of 32 million and is comparable to Maharashtra State in India. The average precipitation for the overall area of the country is 598 mm. The areas of heavy precipitation are situated in the south and in the north of the country and those of lesser precipitation lie in the belt of great valleys in midland. The main river systems traversing through Poland are Vistula and Odra rivers and partly Warta river. The heaviest mean precipitation is 1500 mm observed in Tatra mountains, the least being 450 mm in the upper basin of Notec river. The mean annual runoff has been estimated to be (53.4 cubic km) 53400 million cu. m. per year in very dry years. The annual runoff of all the rivers falls down to 35000 million cu.m. per year. In exceptionally wet years it increases to 90,000 million cu.m. In spite of relative abundance of lakes the quantity of the water resources in Poland is comparatively small. The water resources of some of the countries are given below:-

U.S.S.R.	15000	cu.metre per capita
France	3400	-do-
Switzerland	4000	-do-
U.S.A.	8600	-do-
India	3350	-do-

with a world mean of 10000 cubic metres per capita per year. In view of the acute shortage of water resources in Poland, efforts are being made for optimum utilisation of available water resources to meet the industrial, irrigation and other requirement of the country.

Hydro-Power Development - Poland ranks among the countries owning rich deposits of hard coal and lignite whereas its water resources are scarce. About 98.1% i.e. about 47.7 thousand million kwh, out of the overall production of electric power comes from Thermal power and only 1.9% i.e. 850 million kwh from water power which is only 11% of net water power potential. The estimated water power potential is about 7694 million kwh with an installed capacity of 3100 MW. It is planned to increase the capacity to 6,000 MW in the year 2000 A.D.

Vistula River Development - A systematic development of Vistula river is planned.

Vistula is the biggest river in Poland which drains into Baltaic sea. It starts its course in Western Beskid mountains at the elevation of 1100 metres above sea level. It has a total catchment area of 194000 sq. km. of which 168000 sq. km. is situated in Poland. The total length of the river course is 1068 km. The development of Vistula has been planned in three stretches - the first stretch is

called Upper Vistula Development. The longitudinal slope of this river in this stretch varies from .43 to .27 per cent. The second stretch called the Middle Vistula ends at the confluence with Bug river. The third stretch called the Lower Vistula river starts from Bug river upto the outlet to the sea. (See Fig. 1). This river bed of the whole course consists of fine sand. One of the main characteristics of the Vistula river is that it created acute problem of bed load precipitation which results in sand bar formations and frequent changes of the river course. The energy potential of Vistula River Development constitute about 43% of total energy potential of Poland which is 4,000 million kwh. Out of this, 50% energy potential is constituted by upper reach, 12% by middle reach and 24% by lower reach.

The final aim of development of this river is to build a cascade of 13 to 14 barrages on upper reach. At present a cascade of 3 dams is envisaged for the lower Vistula river. All of these are to serve as baseload power stations and it is planned to reach a mean annual production of about 3500 million kWhs. It is also planned to make this reach navigable for sets of four barges of 500 tons each. The first project to be implemented on this reach is Wloclawek Project.

Description of some of the projects visited is given below :-

1. WLOCLAWEK HYDRO-ELECTRIC PROJECT.

It is the first dam to be constructed on the lower Vistula river. The project will not only develop power but will also afford navigation facilities to a certain extent and afford protection against floods to the adjoining areas. It will also supply adequate drinking water for the industrial establishments which are fast growing up. The Project consists of spillway, power plant and navigation lock.

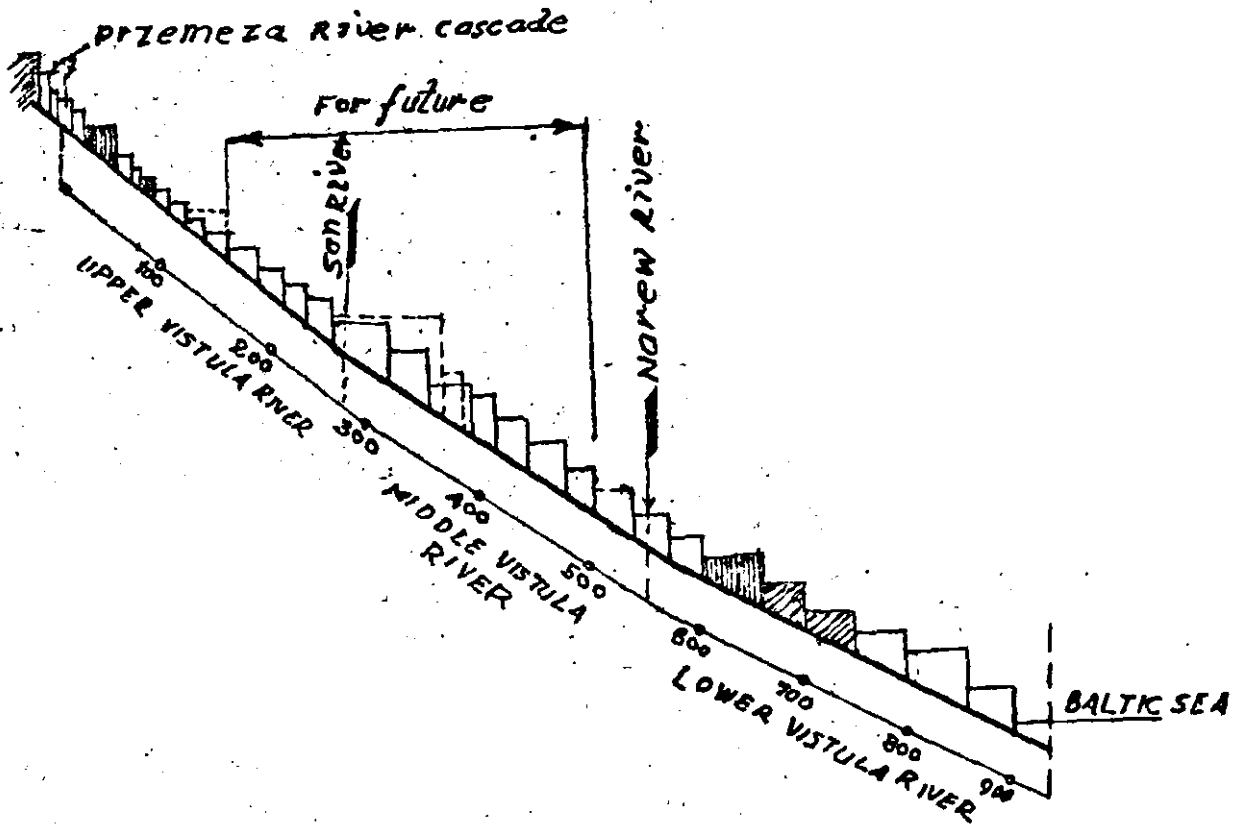
The salient features of this dam are described below:-

Location - Across river Lower Vistula

(1) Geology

The geological condition of Lower Vistula river is very complex and unfavourable.

The foundation consists of tertiary and quaternary formation consisting of sands and aggregates, rarely coarse gravels or cohesive soils. This is formed as a result of erosion and accumulation process as well as glacial action.






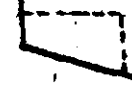
-  The barrage under construction
-  The barrage proposed for realisation in first turn.
-  " " " " " " " next turn.
-  The alternative barrages.

FIG. 1. VISTULA RIVER CASCADE

(2) Hydrological data.

Catchment area	-	171250 sq. km.
Mean annual discharge	-	930 cumecs.
Min. discharge for navigation	-	250 cumecs.
Min. discharge	-	140 cumecs.
One in hundred year flood	-	11150 cumecs.

(3) Dam and appurtenant works

Type	-	Hydraulic Fill Type Earthen dam.
Max. height	-	20 m.
length	-	650 m.
U/s slope	-	1 : 3
D/s slope	-	1 : 5
Earthwork quantity.	-	1.1 million cu.
Upstream face protected by concrete slab 20 cm. thick.		

(4) Weir

10' gates of 6.5 m. x 20 m.

(5) Discharge Capacity - Navigation lock

Capacity	-	Displacement of 1600 tonne.
u/s gate	-	Radial gate
d/s gate	-	Vertical lift gate.

(6) Power Plant

Installed capacity	-	6 units of 27 MW each
Type of turbine Head	-	Kaplan turbine
Discharge through turbines	-	2190 cumecs.
Crane capacity	-	2 of 160 tons each.
Type of power house	-	Semi-outdoor type

(7) Construction stage

The work on the project was taken up in 1963 and the erection of 1st unit in power plant was completed in 1968. The Project is almost nearing completion and is expected to be commissioned at the end of this year. During the construction, coffer dam was made on the right flank. The earthwork on coffer dam was started in the

year 1962 and closed in the year 1964. It was designed for passing a discharge of 7000 cubic metres but during construction, the discharge did not exceed 6000 cubic metres. The concreting of spillway, Power House and Navigation lock was taken up in subsequent years. The cost of the Project was stated to be 2100 million Zloyts (Approx. Rs. 70 crores).

(8) Special Features

i. The main difficulty encountered during the construction of dam on lower Vistula river is dewatering of excavated pit due to high water table. The problem was solved at a very high cost by construction of extensive drainage system including drainage pumping station. On this dam, 11 pumps of capacity 11.6 cumecs were used for dewatering the excavation pit. (Fig.2)

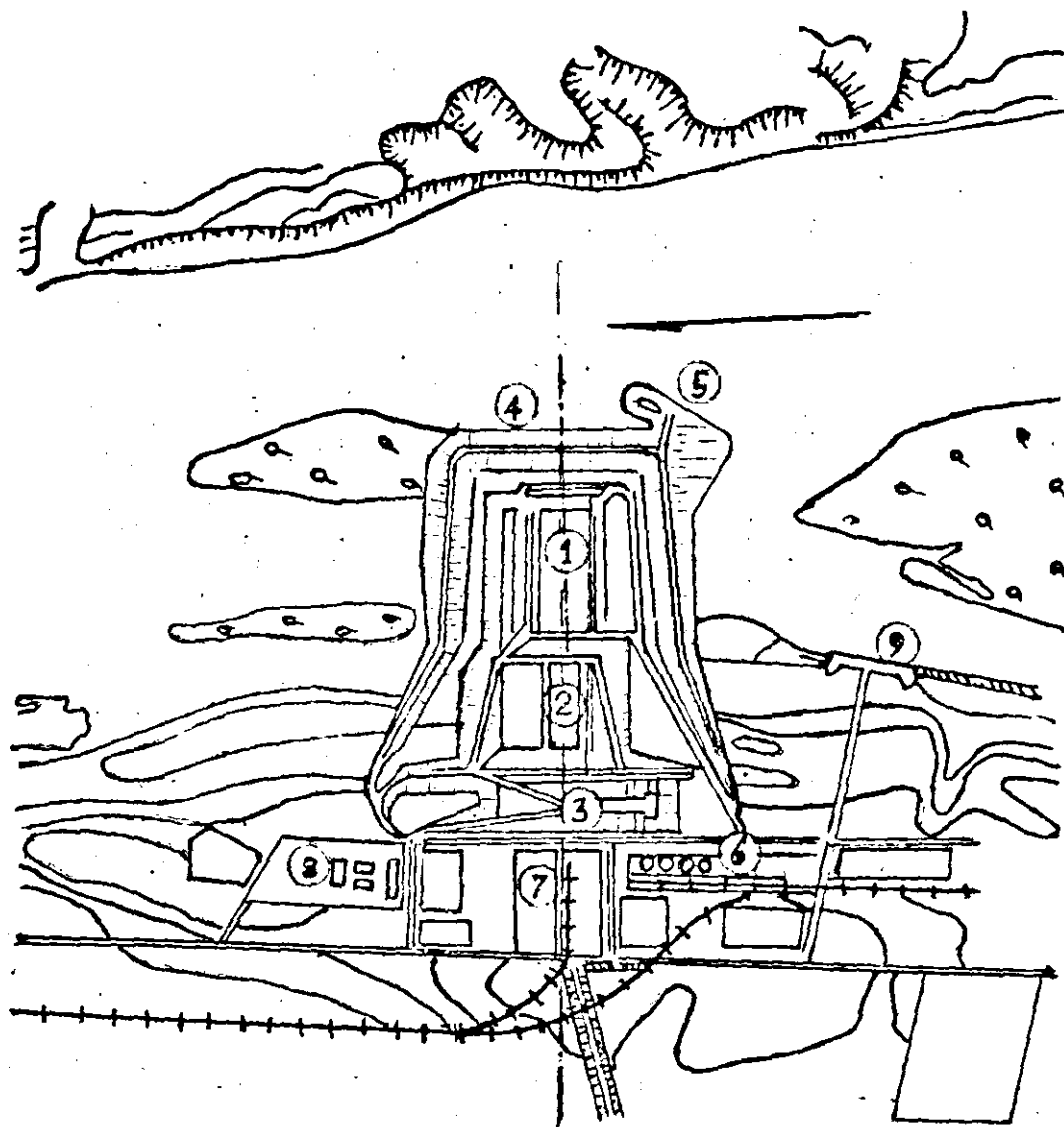
ii. The other problem was the safety and protection of coffer dam slopes against scour and this was achieved by providing special guide or heavy spur dyke located on the upstream corner of coffer dam for creation of convenient hydraulic regime in the narrow river channel.

iii. Foundation in the Power House consists of sandy clay brown colour and lignite. The Power House is designed for a maximum settlement of 20cm, of which 10 cm. settlement has already occurred during the construction.

iv. Six fixed steel gates of 20 x 6½ metres have been installed in spillway. The top of the gates are made smooth by providing steel plates to allow drift and flow of ice. The RCC concrete projecting wall of 1 meter height is made in the middle of the crest of the barrage to facilitate lowering of the gate and allowing the flushing of the ice during the winter. (See fig. 3). The fish ladder is provided in the divide wall between the barrage and the power house.

v. The weir is founded on permeable soil and scour below weir is limited by :-

- (a) Limiting discharge over apron to about 30 cumecs/m. at maximum probable flood to about 40 cumecs meter length at standard design flood.
- (b) Providing suitable protection works for a longer length of 30 to 100 metres. The first section consists of rigid elements in form of fascine mattress loaded by stones.
- (c) Provision of deep sheet pile cut off on downstream.
- (d) By ensuring prescribed schedule of gate operation.



- | | |
|---|--|
| 1. Building excavation of the weir | 2. Power plant excavation |
| 3. Navigation lock excavation | 4. Earth coffer Dam |
| 5. Groyne fastened with concrete plates | 6. Storage yard for the parts power units. |
| 7. The concrete-mixing plant | 8. Administration and social building |
| 9. unloading wharf. | |

FIG. 2 - WLOCLAWEK PROJECT
LAYOUT OF DIVERSION WORKS

ii) Geology

The foundation consists of sandstones with crushing strength of 700 to 1200 Kg/cm². Grouting was extended to a depth of 60 metres to a width of 6 metres.

iii) Reservoir

Area of reservoir	2105 hectares.
Length of reservoir	26.6 km.
Storage capacity	500 milcum.
Live storage	300 milcum.

iv) Dam

Concrete gravity dam

Height	82 metres
Length	664 m.
Concrete quantity	760,000 cum.
Top width	8.8 m.
u/s slope	.05 : 1
d/s slope	.075 : 1
Spillway block	3 bays of 6.5 x 14.0 m controlled by Taintor Radial Gates.
Discharge capacity of spillway	1386 cumecs.
River outlets	2 of 2.8m dia steel lined outlet pipes.
Discharge capacity of outlets	330 cumecs.

v) Instrumentation

They have used in this dam 54 pizometers in the foundation gallery, 82 thermo-meters, 368 strain gauges and 4 strain elasticity measuring instruments, 4 pendulums with extensometers. Systematic measurements of these instruments have been maintained and it has been observed that the dam has settled by only 1 mm in the last three years.

vi) Penstocks

No. and dia of penstock feeding turbo generator	5000 mm.
No. and dia of penstock feeding reversible turbine pump	4000 mm.

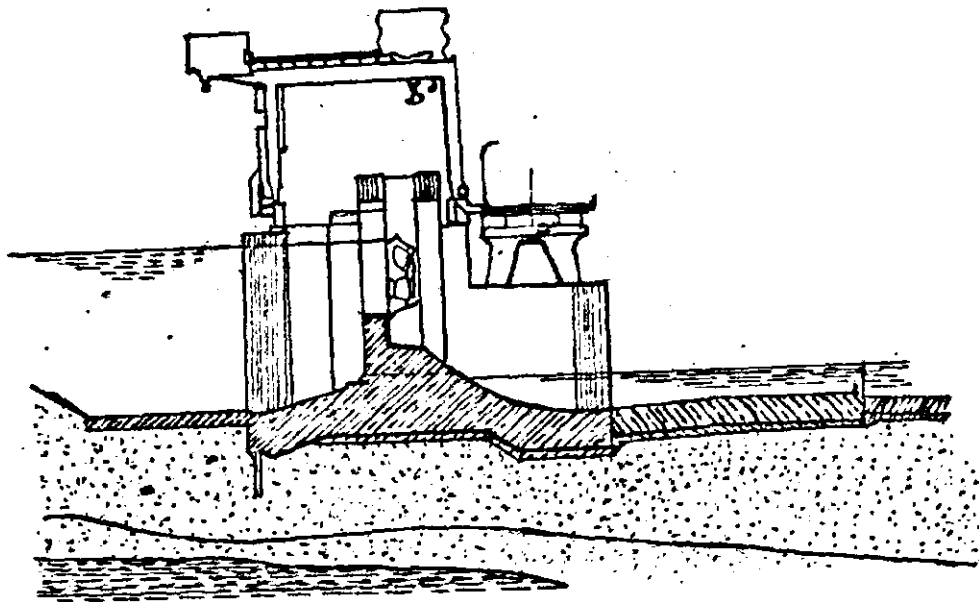


FIG. 3- WLOCLAWEK PROJECT
CROSS SECTION OF THE WEIR

LEGEND

- ⊙----- Towns
- Villages
- ~----- Rivers & Reservoirs
- ⊕----- Water Power Plants
- ▭----- Dams
- ▭----- Fish ponds
- ||----- Roads.

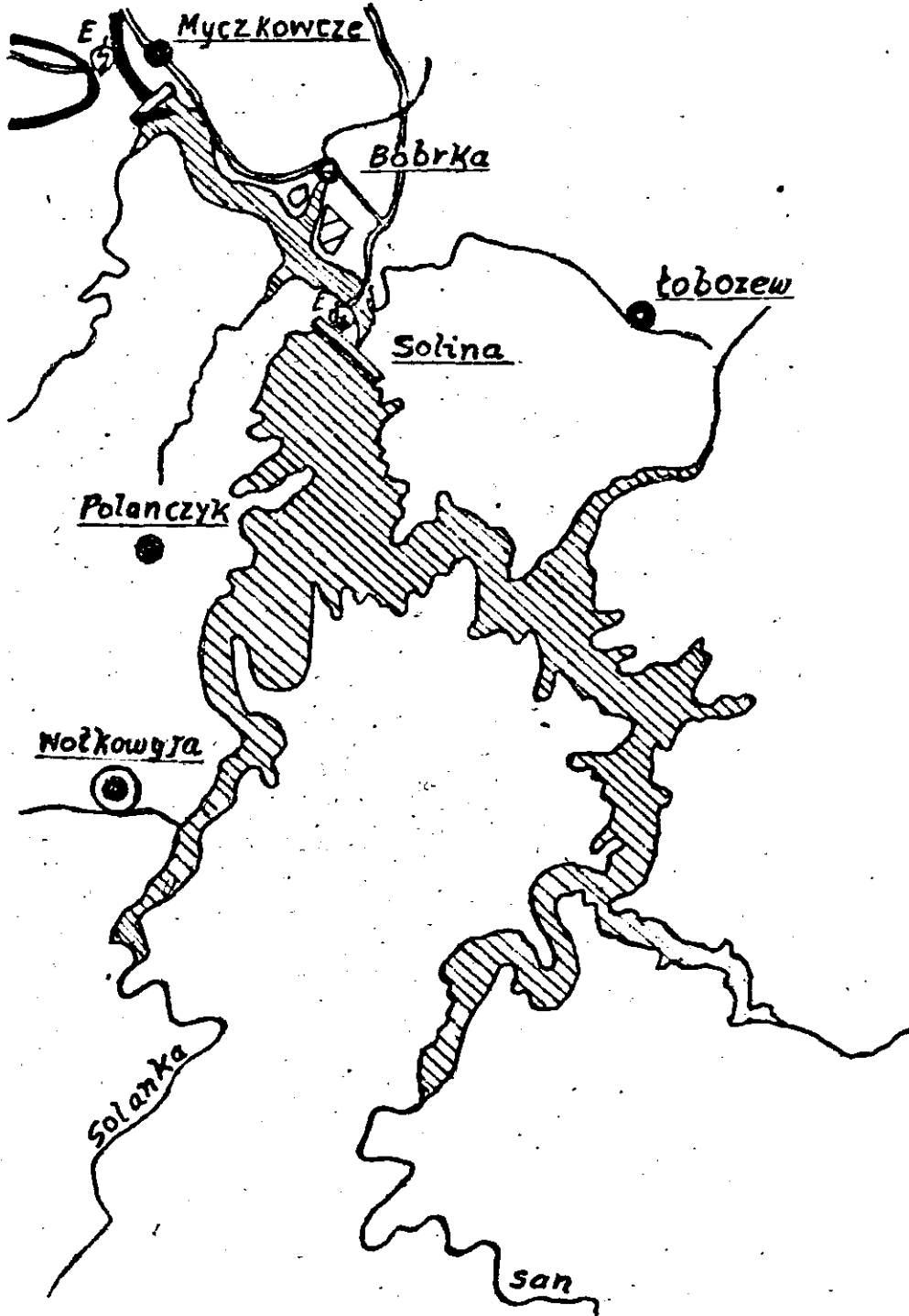


fig. 4

LAYOUT OF SOLINA & MYCZKOWCE
RESERVOIRS

viii) Power Plant

Power plant consists of two turbo generator and two reversible machines.

1. Standard Turbo Generators

Type of turbines	Francis turbine
Size and No. of Units	2 of 46 MW each.
Speed	136.5 rpm
Average head	50 m.
Maximum head	60 m.
Design head	43 m.
Maximum discharge	137.0 cumecs

2. Reversible Units

Type of Francise	Reversible, vertical turbines.
Power generated	22.5 MW per unit
Maximum discharge	420 cumecs.
Pumping capacity	43 cumecs.
Maximum pumping head	60 m.
Design head	60 m.
Crane capacity	2 of 120/20 tons.

(viii) Construction stage

The construction of project started in 1961. The construction of project involved 1.62 million cu.m. of earth work and rock removal, 0.82 million cu.m. of concreting, 73,000 cu.m. of precast concrete units, 20,000 cu.m. of grouting etc. The concreting of dam took place between Sept. 1963 to December 1967 and the Power Plant with pumping units commissioned in 1968.

The stages of construction programme were made with independent coffer dams. In the first stage, the right end half of river was closed by coffer dam. The upstream and downstream coffer dam were made of earth with adequate slope protection on water side, the central coffer dam parallel to the river was about 235 m. long and of fill type with concrete core. The water face was secured by rock weighing 60 kg. each and concrete slabs of 250 mm thick.

In the second stage, the left half of river was closed by coffer dam on upstream and downstream. The longitudinal coffer dam in centre was provided by divide wall and spillway block already constructed during 1st stage.

The upstream and downstream coffer dams were of rockfill type with water face protected by 250 mm thick concrete slab. According to construction schedule the concrete placing had to reach a peak of 2130000 cu.m. and hence two concrete mixing plant of 60 m³ per hr were used and in a continuous operation a maximum volume of 660 m³ was placed.

(ix) Special Feature

i) The power plant consists of four turbo units out of which two are reversible turbines (see fig.5).

ii) To speed up the construction the power house is made of steel structure filled in by precast concrete units.

iii) To meet the tight construction schedule for placement of concrete, a 705 m. span cableway of radial type, with one tower fixed and other movable with two lines was used. The total lifting capacity was 2 x 20 tons. This has a special design enabling the two units to be synchronised in operation so that a single load of 40 tons could be handled and thus enabling the heavier machine parts of power plant to be carried and placed in position as quickly as possible.

iii. MYCZKOWCE PROJECT

General

Myczkowce project consists of a dam across river San, downstream of Solina dam. The reservoir formed by construction of dam acts as a tail balancing reservoir to formed ensure the working of Solina Power Plant as a peaking station. The project also consists of a power plant which operates in coordination with Solina power plant. The salient features of project are as below:

Salient Features

(i) Hydrological Data

Catchment Area	- 1248.0 sq. km.
Mean annual Rainfall	- 929 mm.
Discharges Recorded	-
Minimum	- 1.1 cumecs.
Mean Annual	- 20.1 cumecs.
Maximum	- 1030
1 in Hundred year Flood	- 1600 cumecs.

(ii) Reservoir

Reservoir Area	- 200 Hectares.
Length of Reservoir	- 6 km.
Storage capacity	- 10 million cu.m.

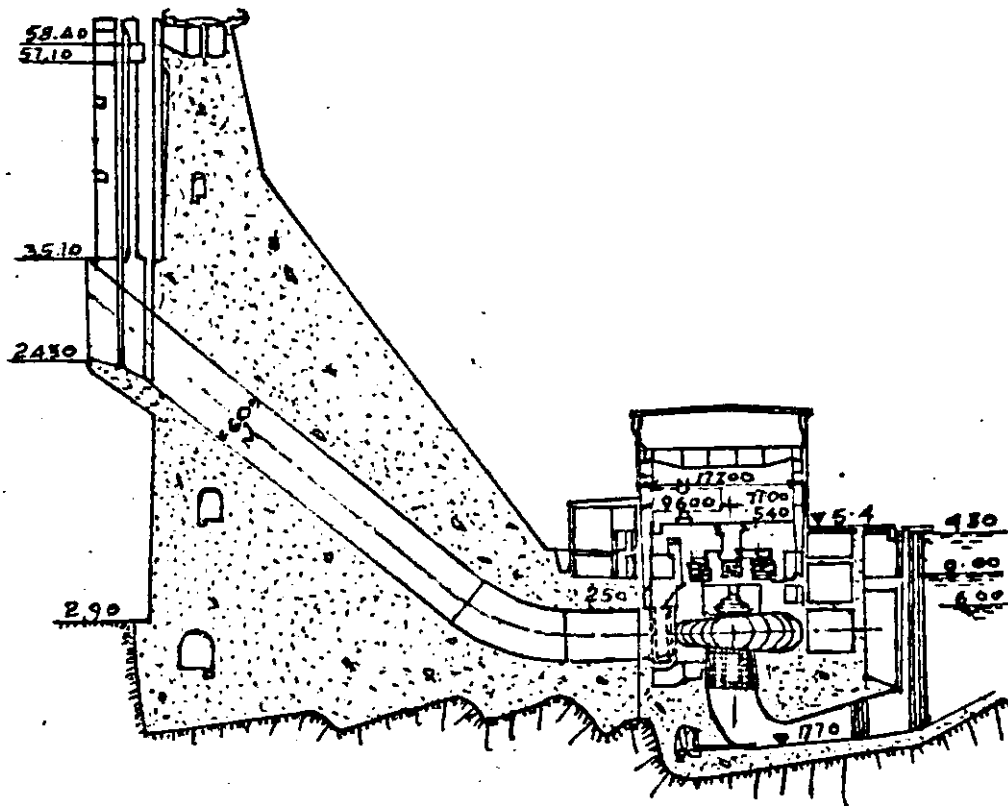


FIG.5-SOLINA PROJECT

CROSS SECTION OF THE POWER PLANT

(iii) Dam

Type of Dam	- Earthen Dam with a clay core.
Height	- 23 metres.
Length	- 460 metres.
U/s Slope	- 3:1 and 2.5:1
D/s Slope	- 3.1:1 and 2:1
Spillway	- 3 bays of 5.5 m x 16 m, controlled by Radial Tainter gates.
Top width	- 9 m.
Discharge capacity	- 1940 cumecs.

The upstream face protected by riprap and 20 cm. thick concrete slab. (See Fig.6). Intake tunnel is located next to spillway controlled by sliding gate.

(iv) Water conductor system

R.C.C. cut and cover conduit	- Dia	- 4.5 m.
	- Length	- 227 m.
	- Wall thickness	- 45 cm.
Tunnel	- Dia.	- 4.50 m.
	- Length	- 4250 m.
Discharge	- 45 cumecs	

(v) Power Plant (See Fig.7)

Type of Turbines	- Kaplan Turbine
No. and size of unit	- 2 of 4.15 MW each.
Average head	- 22.8 m.
Speed	- 300 rpm

iv. ROZNOW PROJECT

Two reservoirs of Roznow - Czchow are formed by construction of dam across river Dunajec River, a tributary of Vistula River. The main purpose of construction of these dams is (i) Flood Control (ii) Power Generation (iii) Improvement of inland navigation (iv) To meet water demand of industry and population. Roznow project was completed in 1943 and Czchow project in 1954.

Roznow Project.

Location - Across river Dunajec River.

Hydrological Data

Catchment Area - 4865 km²
Mean Annual Rainfall - 810 mm.

Recorded Discharge

Minimum - 3 cumecs.
Average Annual - 64 cumecs.
Maximum - 2600 cumecs.
1 in 100 years - 2695 cumecs.

Geology

The foundation consists of Carpathien flysh which is a sedimentary formation consisting of alternate beds of hard sandstone, medium hard conglomerates and soft clayey shale. The thickness of sandstone beds varies from few cm to 2 metres conglomerate bed is about 1 metre thick and thickness of shale bed varies from 2 to 10 c.m. The beds dip in the direction of reservoir at an angle of about 25° to 30° .

Reservoir

Area of reservoir	- 1600 hectares
Length of reservoir	- 22 km.
Live storage	- 1386 million cu.m.

Dam

Type of dam	- concrete gravity dam
Maximum height	- 49 m.
Length	- 550 metres
Quality of concrete	- 450 cu.m.
U/s slope	- 0.04:1
D/s slope	- 0.8:1
Crest width	- 6 m.
Spillway	- 7 bays of 6 m x controlled by Taintor gates.
Discharge capacity	- 2780 cumecs.
River outlet	- 5 of 2.7 x 3.5 m controlled by hydraulically operated sliding gates.
Discharge	- 200 cumecs per outlet.

Power

Power station is located in the downstream of the dam creating niches in the body of the dam as shown in Fig. 8

Type of Turbine	- Kaplan
No. and size of units	--4 of 12.5 MW each
Firm power	- 43.2 MW.
Speed	- 214 rpm.
Maximum Discharge	- 50 cumecs.
Average Head	- 26.5 m.
Maximum Head	- 31.1 m.
Crane capacity	- One overhead crane capacity 60/10 Tonnes.
Minimum head	- 16.6 m.

MYCHKOWCE PROJECT.

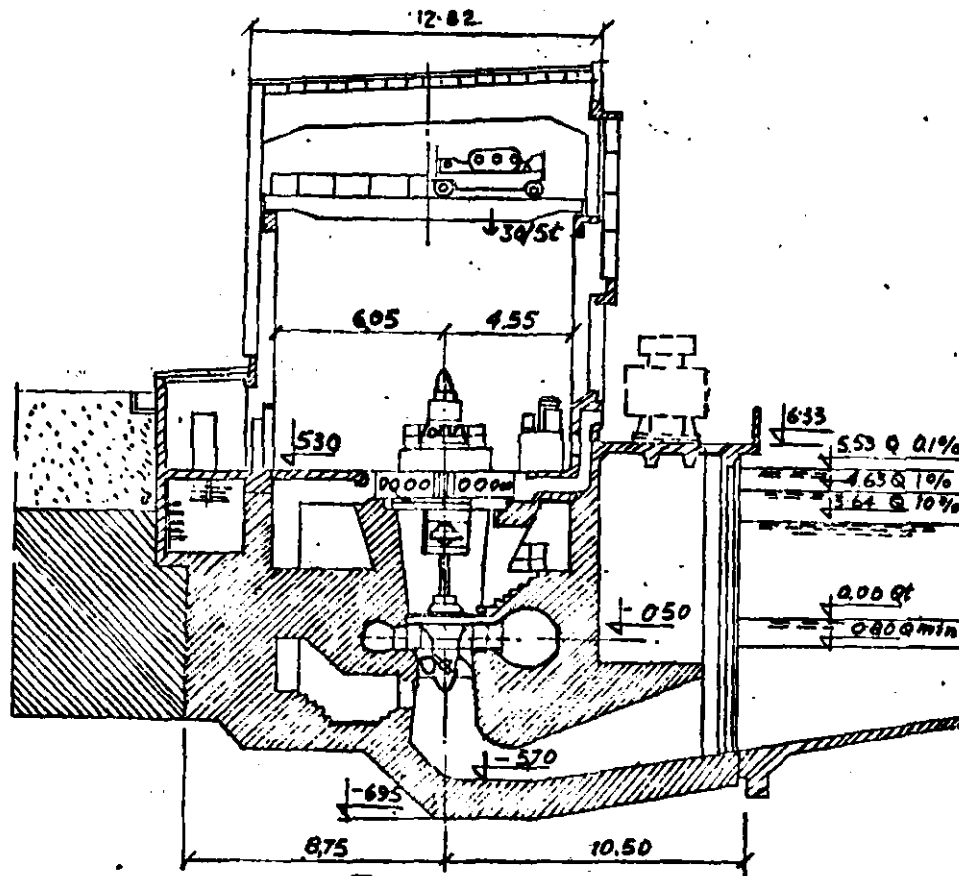
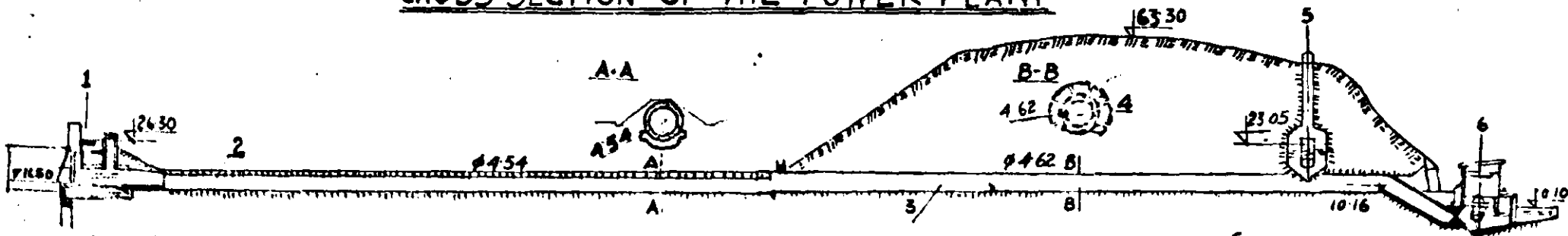


FIG. No. 7
CROSS SECTION OF THE POWER PLANT



1. INTAKE
2. CUT & COVER DUCT
3. TUNNEL

FIG. NO. 6
L-SECTION OF THE WATER INTAKE

4. GROUTED ZONE.
5. SURGE SHAFT.
6. POWER HOUSE.

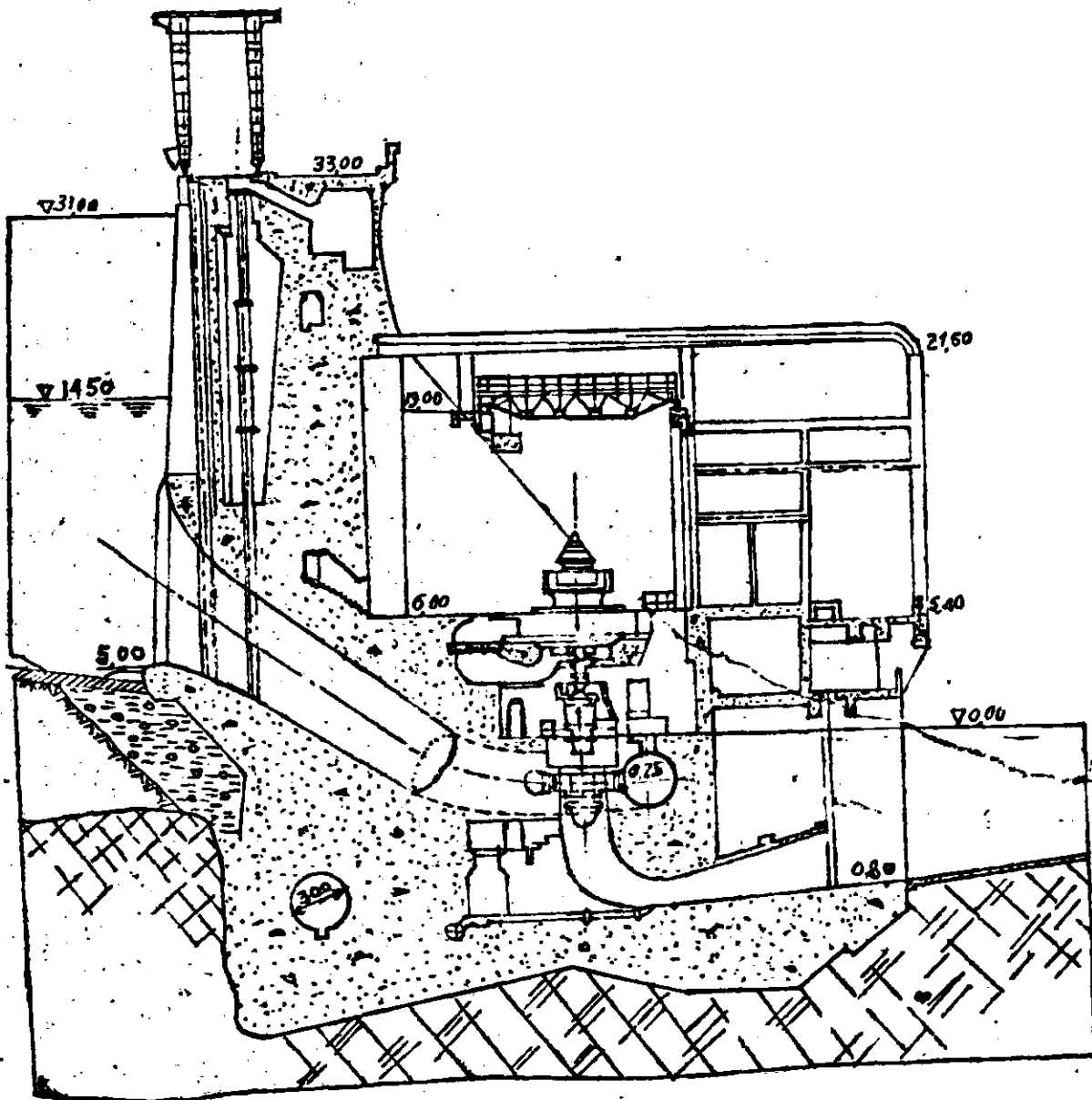


FIG. 8

ROZNOW PROJECT
CROSS SECTION THROUGH DAM & P.H.

Special Features

The power house is located in block Nos. 19, 20, 21 and 22 of width 17 metres each. The units are accommodated in the body of dam by forming a capacity of about 8.5 metres width between two buttress of width 4.25 metres each.

During excavation for the power plant foundations, the existence of two faults was discovered under block 19, 20, 21 and 22 as shown in fig. 9. It was feared that the existence of faults the variable nature of bed rock where modulus of elasticity varies from 40,000 t/m² for shale to 610,000 t/m² for sandstone and variation from monolithic character of dam by locating PE in the cavities within dam body, may cause unequal settlement of foundation and it may develop cracks in Power House foundation. It was also feared that this will be aggravated by the vibrations caused by the running of power house.

The power house foundation slab was suitably reinforced after evaluating the modulus of elasticity of various rocks in situ and stressed in the foundation for the deformation in the foundation along the base.

This dam was constructed during Second World War when the science of rock mechanics had not yet developed and the foundation problem was solved and designed such that even after 20 years the structure is standing without any damage, failure or cracks. (Ref. "Influence de ineterogencite des roches sur la foundation d'un Garrage - Poids en condition due Flysh Garpattien" para Prof. Balcerski - R. 38 - Eighth International Congress on Large Dams).

5. CZORAZTYN - NIEDZICA PROJECT

General

Czoraztyn - Niedzica Project is under investigation and it envisages the construction of dam across river Dunajec river for (i) flood protection on Dunajec river valley (ii) regulation of downstream discharges of Vistula river basin and (iii) development of power. During the designs, maximum attention will be paid to limit the submersion and to ensure maximum protection to historic buildings, monuments and landscapes in tourist region.

Geology

Lime stone belt about 80 m. wide.

Dam

Type	Concrete gravity dam
Height	60 m.
Length	400 m.
Quantity of concrete	328000 cu.m.

Foundation treatment

Two rows of cement grout curtain below dam in the river bed and along the left abutment for a depth of 55 m. is proposed to reduce filtration underneath dam and through abutments.

Spillway Bays of 5.5 m x 12 m controlled by hydraulically operated gates of 5.5 m locking height (see Fig.10)

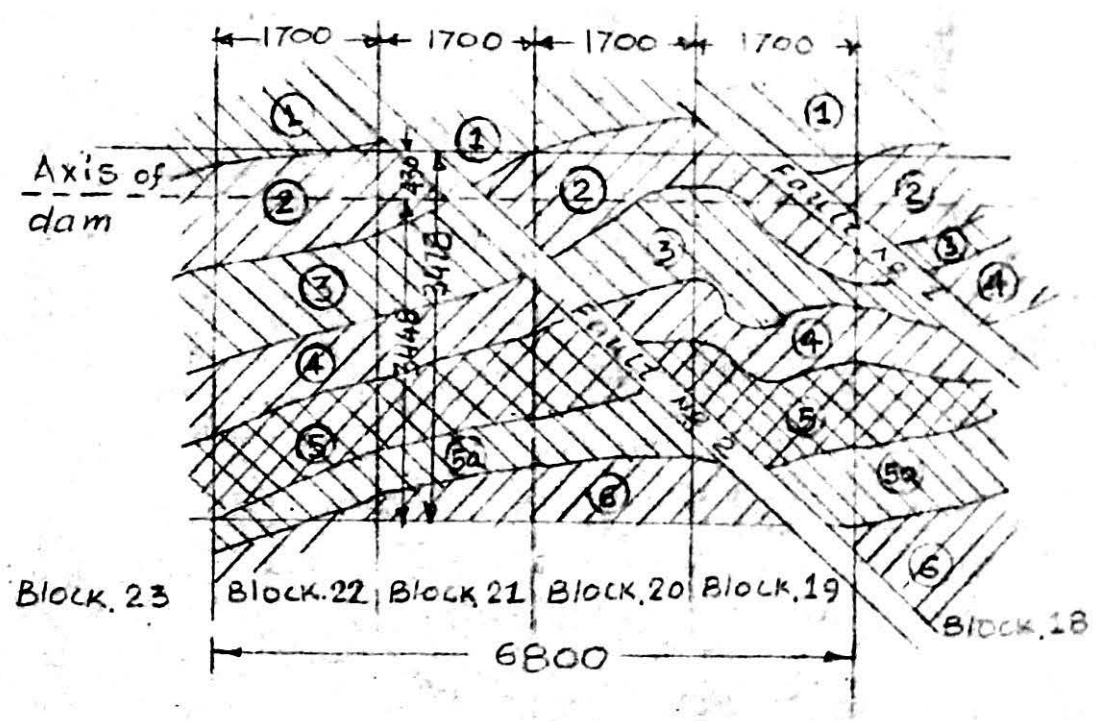
Discharge capacity 1127 cumecs.

River outlet Two openings of 2.3 m. in the central part of spillway controlled by hydraulically operated sliding gates.

Power Plant

The power plant will be located 30 metres away from dam, and consists of two units - one standard Kaplan turbine and another Deriaz reversible machine. The water to units is fed by steel penstocks (See Fig.11).

Installed capacity-	74.4 MW
Standard Kaplan Turbine unit capacity	38.0 MW
Discharge	125.0 cumecs.
Reversible Deriaz turbine Unit:	
Generating capacity-	36.4 MW
Discharge	= 125.0 cumecs
Power required for pumping	36.00 MW
Pumping capacity	89.5 cumecs
Generating head on turbine :	
Maximum	49.8 m
Minimum	21.15 m.
Average	35.10 m.



GEOLOGICAL PLAN OF THE FOUNDATION

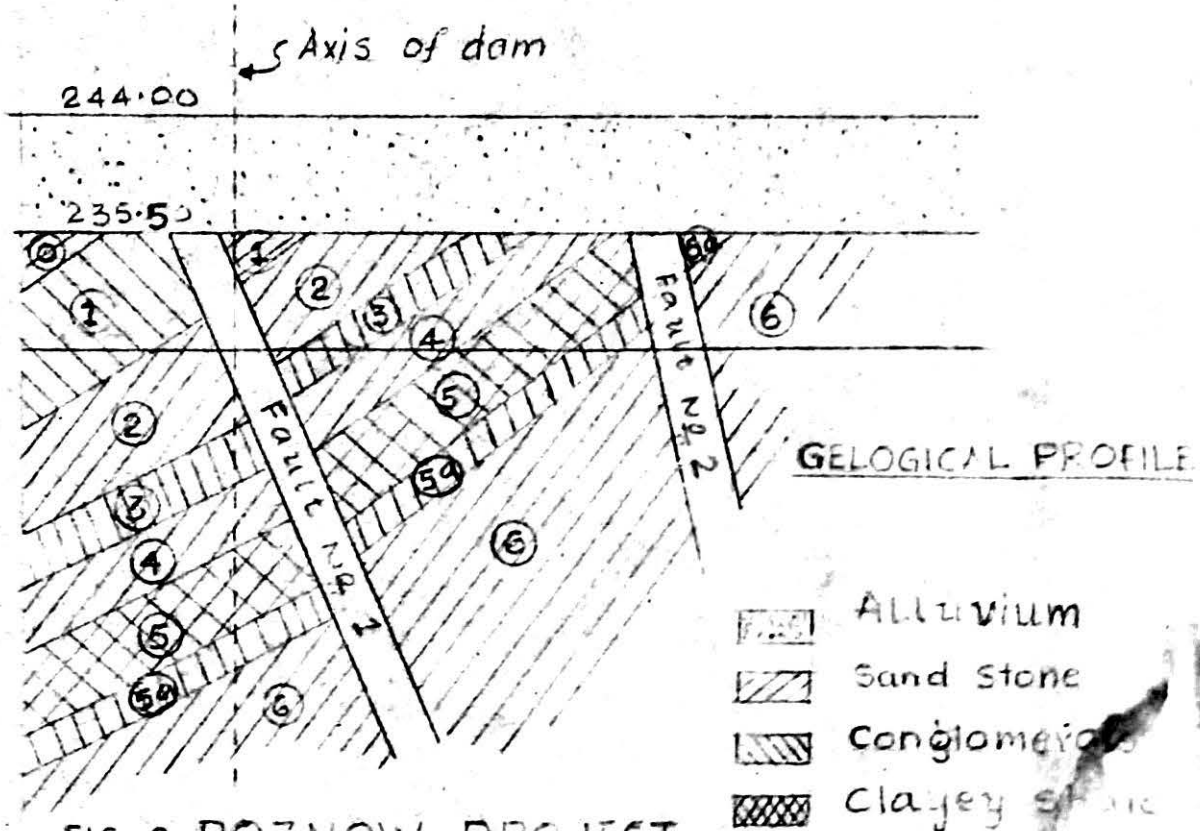


FIG-9 ROZNOW PROJECT
FOUNDATION GEOLOGY BELOW POWER DAM & POWER PLAN

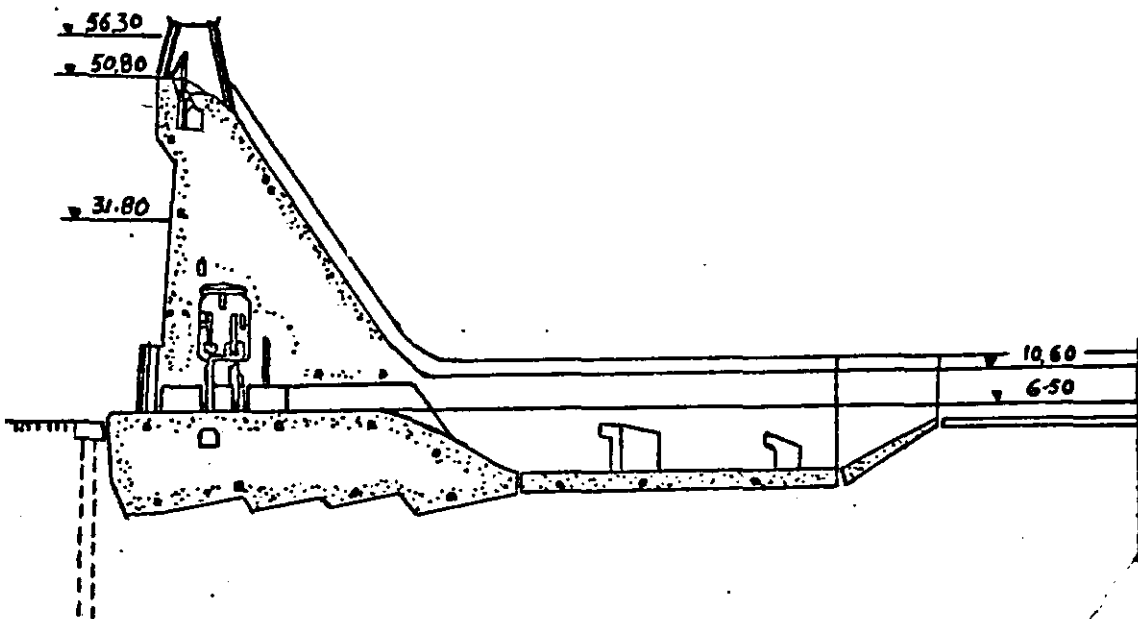


FIG. No 10.

SPILLWAY CROSS SECTION
CZORSZTYN - NIEDZICA PROJECT

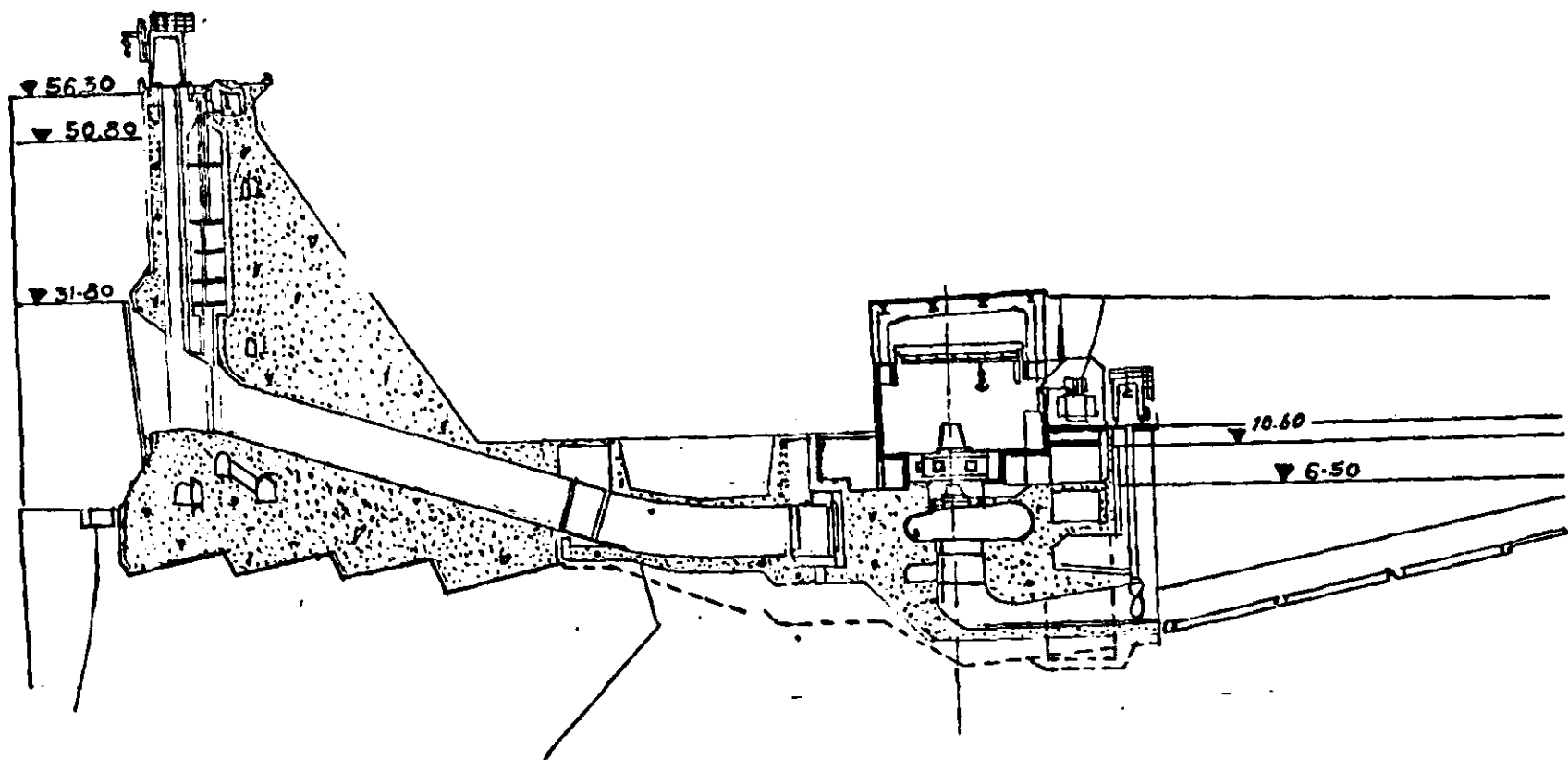
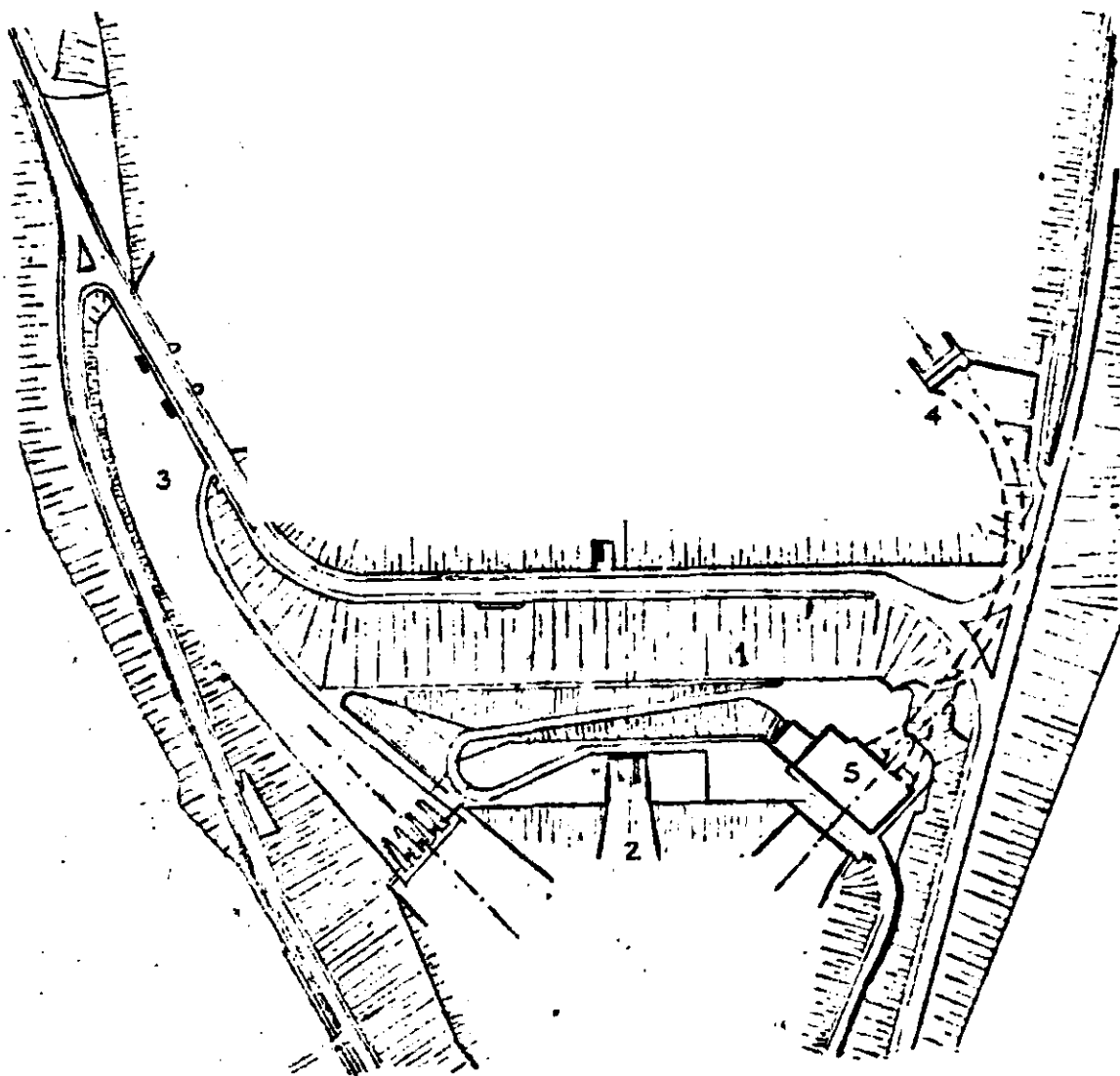


figure 11
CZORSZTYN- NIEDICA PROJECT
CROSS SECTION THROUGH POWER DAM & POWER HOUSE



1. MAIN DAM

2. OUTLET WORKS

3. CHUTE SPILLWAY

4. POWER TUNNEL

5. POWER HOUSE

FIG. NO 12 - TRESNA PROJECT
GENERAL LAYOUT PLAN

Pumping Head:

Maximum	- 44.5 m.
Minimum	- 21.45 m.
Average	- 35.80 m.

Special Feature

Between the dam and grouting curtain top block, flexible joint will be provided and it will guarantee impermeability despite movement of dam.

Investigation Stage

For investigation of foundation rock 1100 drill holes were drilled and field tests in situ were made.

vB. TRESNA PROJECT

General

Tresna is one of the projects built on Sola River Cascade. Sola river cascade was built to (i) augment water supply to Silesion-Cracovian Industrial region, (ii) Flood control (iii) Regulating the discharges of upper Vistula River and (iv) to develop power. Tresna reservoir is important because of its location on Sola river and reservoir capacity. It was constructed in the year 1960-66. The Project consists of Earthen Dam, chute spillway of Power Plant (See Fig.12).

(i) Hydrology

Catchment Area	- 1030 sq. km.
Mean Annual Rainfall	- 913 mm.
Discharges Recorded	
Minimum	- 1 cumecs
Maximum	- 1382 cumecs
Average	- 18.8 cumecs
1 in 100 year flood	- 1469 cumecs

(ii) Reservoir

Reservoir Area	- 1000 hectares.
Storage capacity	- 100 million cu.m.

(iii) Geology

The dam is founded on flysh layers composed of sandstone rock inter-bedded with thin layers of shale.

(iv) Dam

Type of dam	- Earthen dam
Height	- 39 m.
Length	- 300 m.
Top width	- 10 m.
Spillway	- Chute spillway with 3 bays - 2 of 23 m. span and 1 of 15m x 4 m controlled by flap gate.
Discharge capacity	- 841 cumecs

- River outlet - 3 rectangular ducts of 4x4 m, each controlled by hydraulically operated sliding gates.
- Discharge capacity - 730 cumecs.

(v) Water conductor system

The diversion tunnel serves as conduit to supply water to power plant.

- Dis. of Tunnel - 6.7 m.
- Lining - Reinforced concrete lining of thickness 500 m.m.

The discharge is controlled by sliding gates on upstream and butterfly valves on downstream.

(vi) Power Plant

It is a peaking station and location on the downstream of dam. (See fig. 13).

- Type of turbine - Kaplan Turbine
- No. and size of units - 2 of 21 MW each
- Speed - 214.3 rpm.
- Design head - 20.4 m.
- Design discharge - 122 cumecs

(vii) Special Features

During the construction, the land slide over the tunnel intake was observed and cracks appeared on hill slope over an area of 10,000 sq.m. The hill slope was formed of fine sandstone layers 1 meter thick and shale layers 0.2 m. thick dipping perpendicular to valley axis at an angle of 60°.

The investigations also revealed two faults perpendicular to each other and one dipping at an angle 70° and parallel to valley axis and other situated parallel to dam axis about 140 m. away.

The main reason of landslide is the loosening of material due to excavation. The geological exploration did not reveal any distinct sliding surface but the sliding mass have a triangular wedge. The maximum movement of surface observed was 30 mm per month.

The intake tower of the tunnel and dam was protected from sliding surface by providing concrete retaining block and loading the lower part of valley slope by earth fill. The retaining block was anchored in rock by 76 prestressed cables and an expansion joint is provided between retaining block and intake structure so that intake tower is not loaded from earthfill due to movement of slide. Effective drainage of upper part is an additional preventive measure. (Fig. 14).

The observation during the reservoir filling has shown no visible displacements.

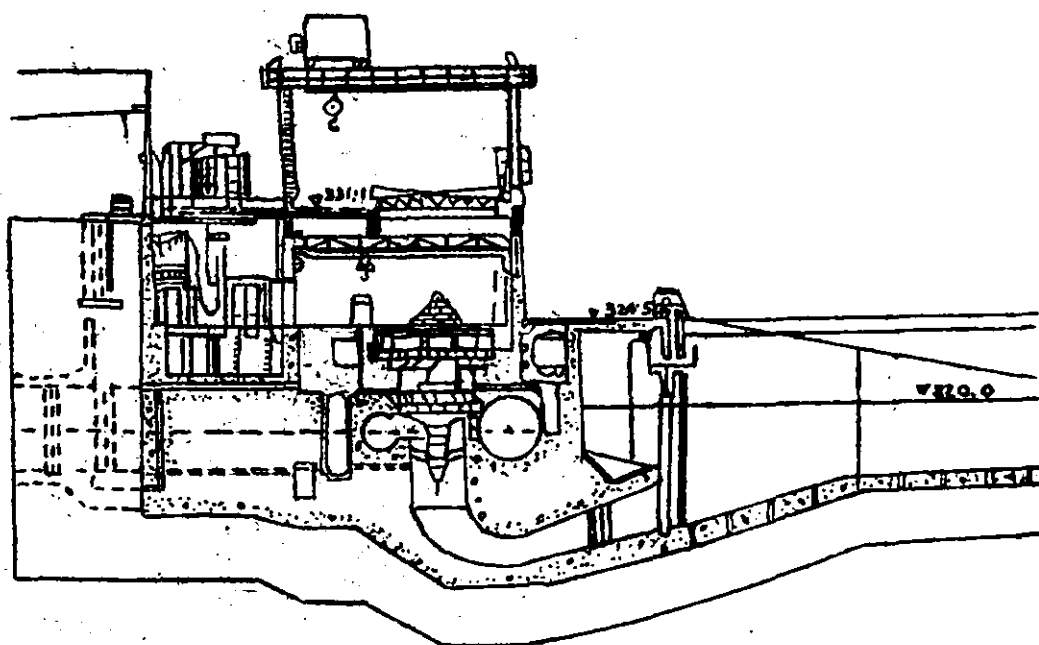
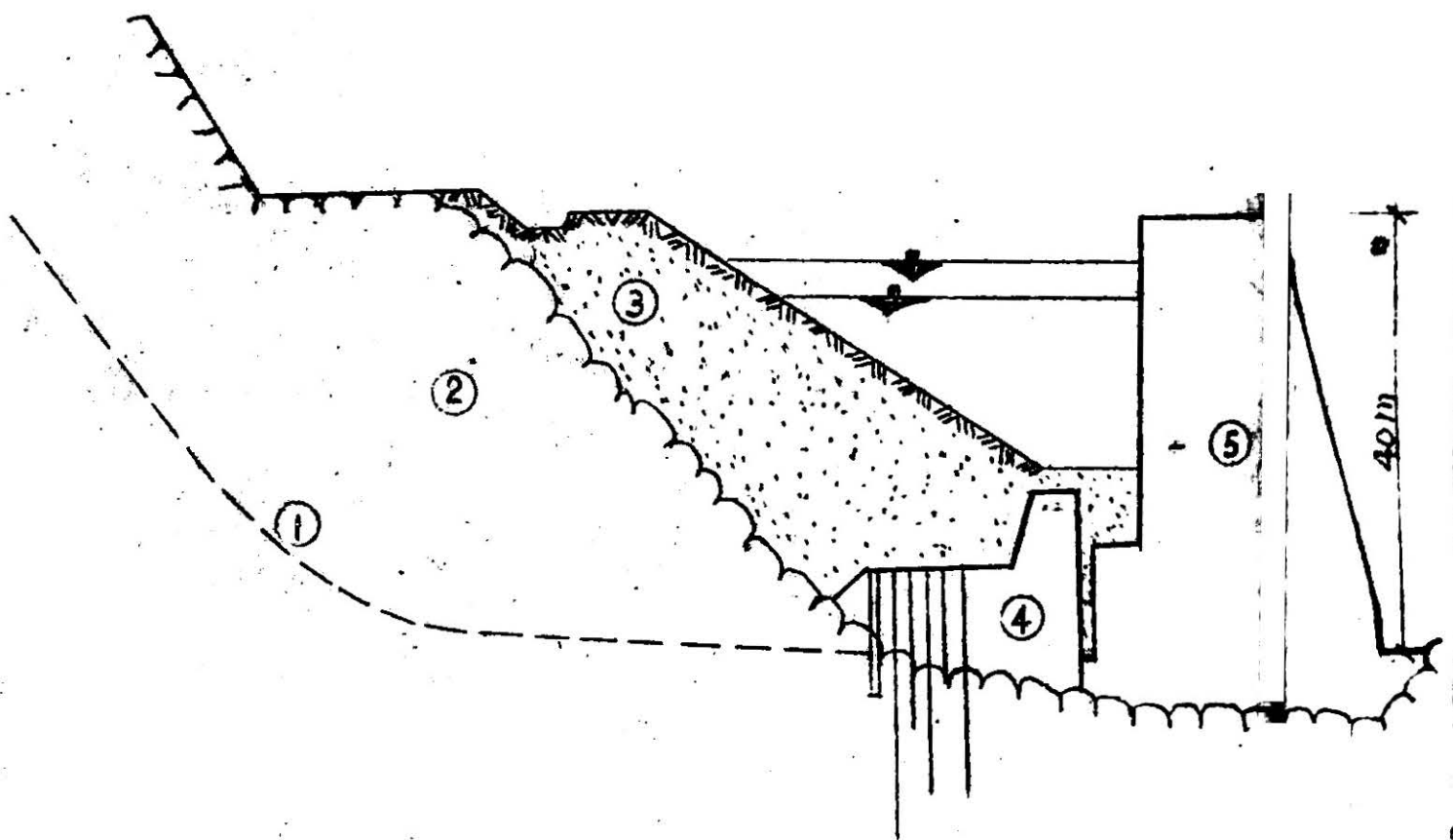


FIG. NO. 13
TRESNA PROJECT
CROSS SECTION THROUGH POWER HOUSE



- | | |
|----------------------------|-------------------|
| 1. SLIDING TRANSITORY ZONE | 2. SLIDING MASS |
| 3. EARTH LOAD FILL | 4. RETAINING LOCK |
| 5. INTAKE TOWER. | |

FIG. NO. 14 TRESNA PROJECT
CROSS SECTION OF SLIDE SLOPE

IN CZECHOSLOVAKIA

Czechoslovakia is a country in the middle of Europe, located between 48° and 51° north latitude and 12° and 22° east longitude. The climate is characterised by mild winters and warm summer with clearly defined spring and autumn seasons. The average winter temperature is about -5° C and average summer temperature around 20° C. It has a total area of 127,859 sq.Kms. with a population of 14 million and is comparable to Assam State in India. There are three principal mountain ranges viz. Bohemia, Moravia and Slovakia and there are three principal river systems corresponding to the above mountain ranges- Bohemia-Labe Vltava, Moravia-Moravia, Dyje and Slovakia-Danube Vah and Hron.

Most of the rivers are short because all of them have their source in the country with the exception of the Danube which forms part of its southern frontier running into three different seas-The North Sea, the Baltic Sea and the Black-Sea. The flow in the rivers is unstable, the ratio between the minimum and maximum flow being 1:500 and even more.

The total Hydro electric potential of Czechoslovakia has been estimated to be about 22 billion KWh of which 12-14 billion can be exploited and in this 8-9 billion KWh economically exploitable. The present hydro power production which is about 3.3 billion KWh is about 20% of the total power production in Czechoslovakia. The principal importance of Hydro power plants is in their utilisation as peak load stations.

Through a small country, it has very complex geologic conditions. The Western part of the country is formed of the geologically intricate Bohemian Massif where the foundation consists of ancient Schists, gneiss, granite and the like. The eastern part of the country is a portion of the Carpathians where the most part of the presence of Flysch rock dictates the choice of dam engineering. The compact region is the Moravian Flysch in the Border strip between Moravia and Slovakia.

The majority of the dams have been built on the river Vltava in Bohemia and the river Vah in Slovakia. These are the largest rivers of the country with the exception of Danube and account for about 40% of all country's energy. Five of the now existing series of ten dams on the Vltava river have been built after 1945, the three main being-Lipno I at the foot of the Sumava Mountains and the Orlik and Slapy dams south of the Prague with a total storage capacity of 13 m.c.m. of water with an installed capacity of 640 MW (fig-1).

The Cascade (fig.2) on the river Vah including its Orava tributary comprises of 16 hydro electric power plants with an installed capacity of over 540 MW.

An interesting innovation in the hydro-electric field is the manufacture of unidirectional reversible set named HCNE after its inventors, Brno scientists Prof. Mirsolav Nechalaba and Vaclav Hosnedi. Reversible sets are used in power stations which, beneath the main dam, have an auxiliary reservoir from which water is pumped back into the main reservoir during the idle hours in order to be used for the production of highly needed electricity during the peak loads of the power grid. The present reversible sets revolve in one direction as a turbine plus alternator and in the opposite direction as a motor plus pump. The transition from one phase to the other which takes place usually four times a day under normal conditions and sometimes more often is accompanied by operational difficulties in the case of more powerful units, especially when the set is started for its pumping function and during its electric braking. The new Czechoslovak invention is reported to eliminate these shortcomings and is of a basic importance for the further development of hydro-electric power systems.

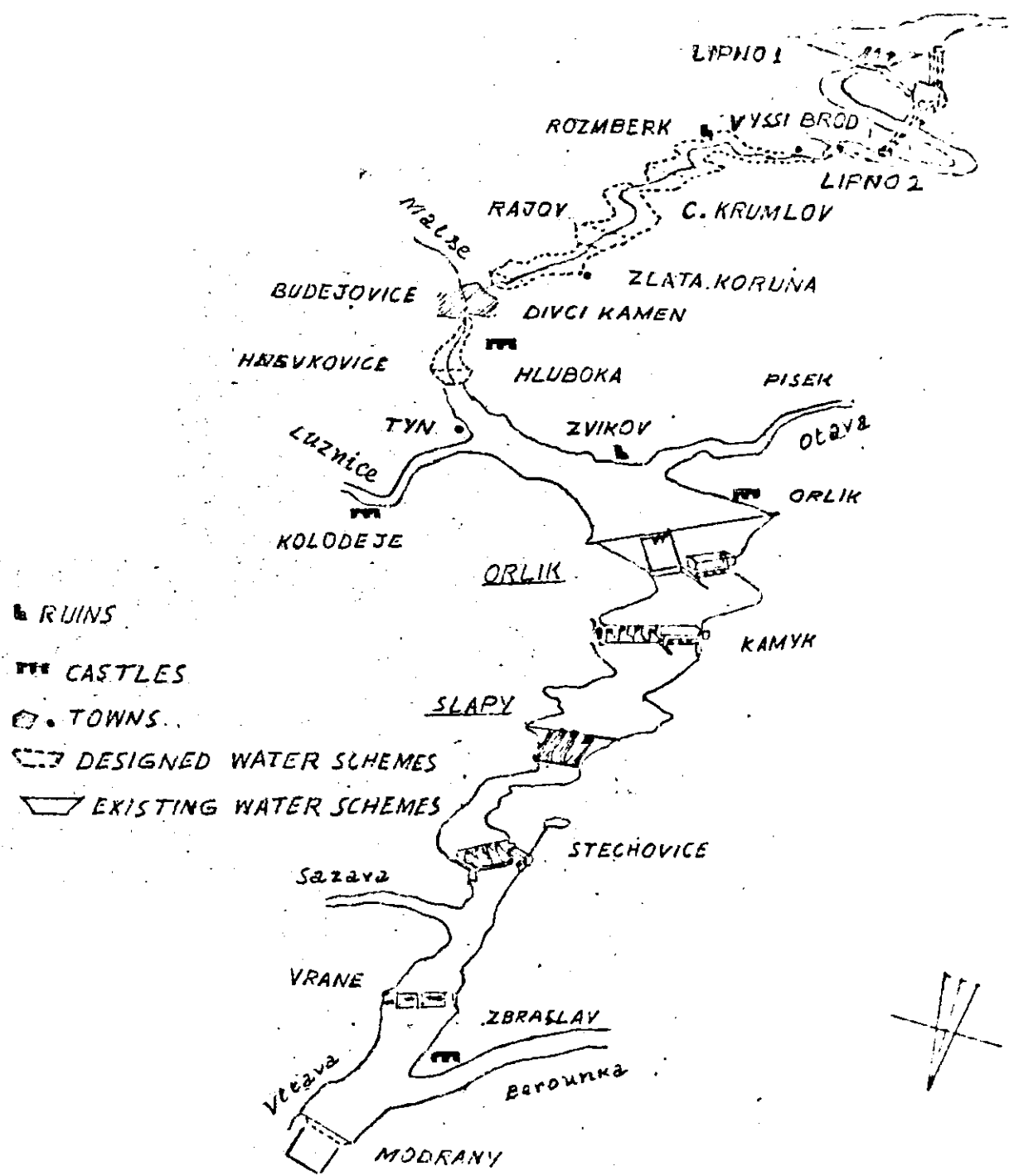
A large number of projects are in various stages of planning, construction and operation through out the country. Projects visited during the study tour are shown in fig.3.

Brief description of important projects visited during the study tour.

1. ZERMANICE PROJECT

The project consisting of a concrete dam 38 m. high and 502 m. long has been constructed across river Luchina a tributary of Odra near Zermanice for water supply to Ostrava and also for flood control.

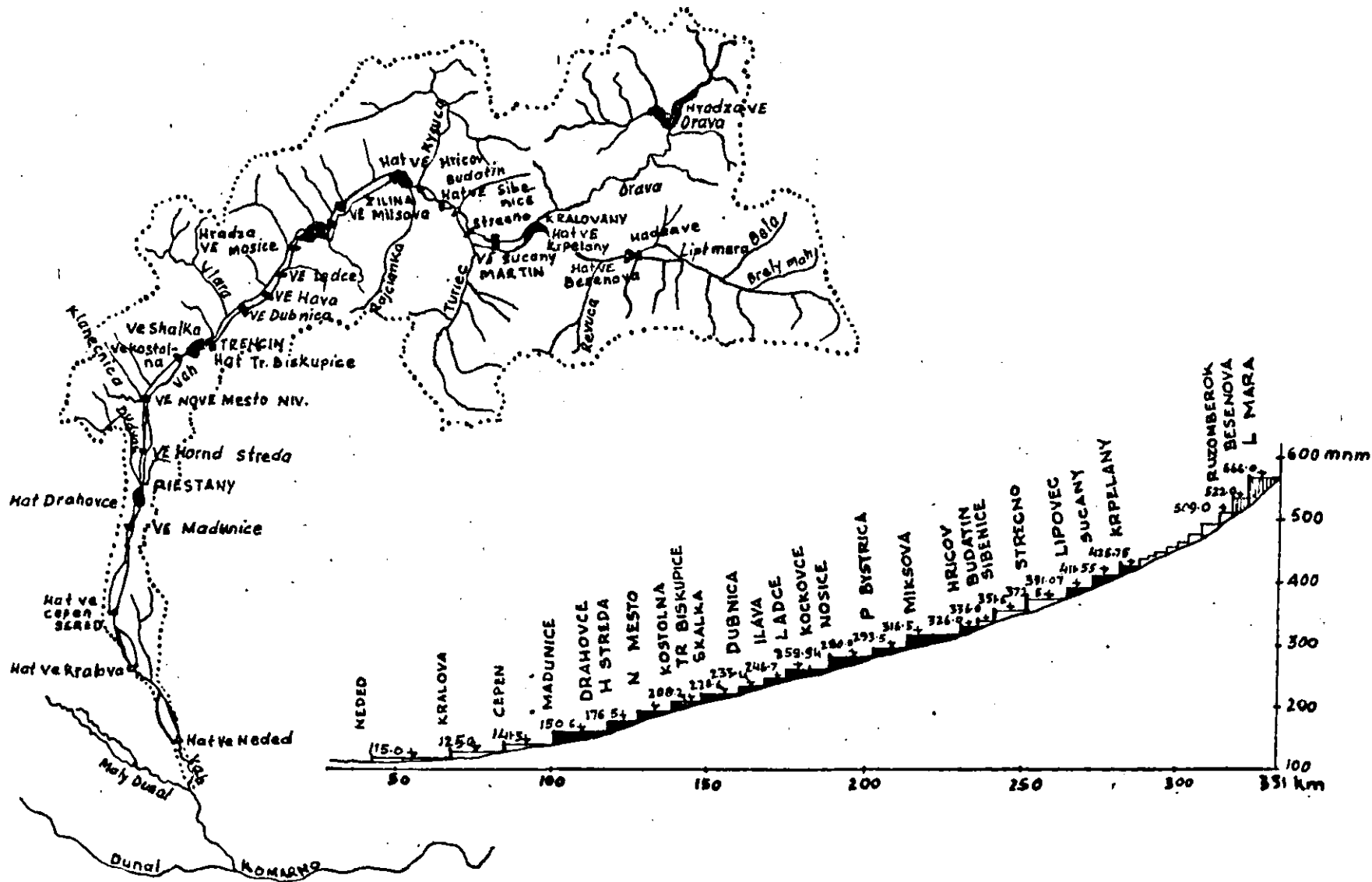
The dam is located in the zone of Carpathian flysch formed of marl shales and teschenite intrusions. There is a 200 m. thick layer of productive carbon of the petrkovice zone 400 metres below the dam. The valley cuts deep into marl shales on both slopes relatively compact teschenites rise to the surface. The marl shales are soft, thinly foliated of grey-brown to black colour, compact in the undisturbed state, falling into places on the air, while in water they



- RUINS
- 🏰 CASTLES
- 🏠 TOWNS
- - - DESIGNED WATER SCHEMES
- EXISTING WATER SCHEMES



FIG No. 1
THE VLTAVA RIVER CASCADE



- ▷ Dams under planning
- ▤ Dams under construction
- ▴ Dams under operation

FIG. 2. VÁH RIVER CASCADE

become soft and slushy. The teschenites penetrated through the marl shale and formed at the site of the dam a bedded vien of variable thickness sometimes reaching 28 m. Tests on shale indicated its shear properties- $\tan \phi = 0.32$ and $c=0.35$ kg/sq.cm.

The above complex geological conditions necessitated the dam to be designed in 3 sections(Fig.4).

- a) The left bank part on teschenite including the spillway blocks is designed as a conventional gravity dam. It comprises blocks 15 to 26 in a total length of 129 m. the maximum height of the block being 34, the width 11 m. (except block No.15 measuring 8 m in width).
- b) The gravity blocks 6 to 14 on shales and the right bank teschenite slope are designed in combination with an embankment on the downstream side.
- c) The mixed sections on the right bank in weathered teschenite is designed as a concrete wall with embankment on the d/s side(blocks 1 to 5 and A-G in a total length of 101.0 m.)

The dam is connected to the abutment by means of concrete cut offs 95.5 m. long on the left and 80 m. on the right. In addition a grout curtain 110 metres long has also been provided.

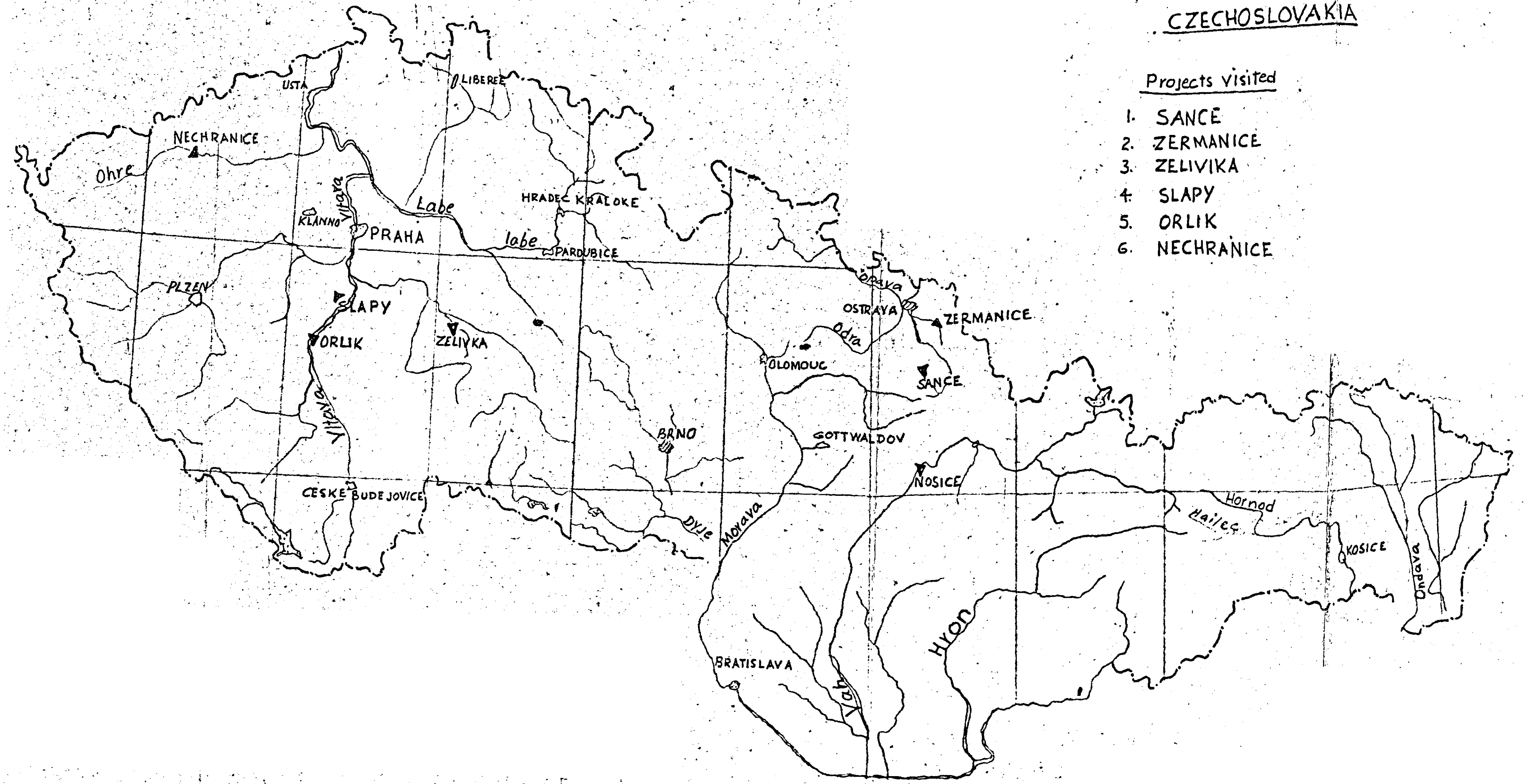
The design of blocks 15 to 26 was carried out to limit the vertical stress s to 10 kg-sq.cm. and with a friction co-efficient of $\phi=0.65$ blocks 14 to 16 are founded on reinforced concrete slabs. Double sided armouring of the slabs has been done to prevent formation of cracks in the dam. The slabs are dimensioned for the most adverse case of deformation of the substratum the elasticity of the slabs and the plasticity of the substratum being neglected.

The stability of the teschenite block on the right hand bank is deteriorating through the action of the flow of ground water in the slopes. The originally planned drainage gallery running at the level of the underlying shales on the d/s side of the dam was abandoned, the water being taken away by means of drains emptying into the drainage gallery in the membrane.

CZECHOSLOVAKIA

Projects Visited

- 1. SANCE
- 2. ZERMANICE
- 3. ZELIVKA
- 4. SLAPY
- 5. ORLIK
- 6. NECHRANICE



During the exposure of the dam base on the right bank, shale disrupted through thrust faulting was met with and further bulging of the shales caused movement of teshenite blocks occurring at the same time. It was, therefore, necessary to remove the disrupted shale. For ensuring stability the blocks, 11, 10, 9 and 8 were founded on plugs constructed in timber, shafts to a depth of 7 m. Different cross sections of the dam adopted at different chainages are shown in fig.4.

12. SANCE PROJECT

The dam across the river Ostravice, a tributary of Odra, at Sance is the highest earth-cum-rockfill dam in Czechoslovakia intended to store about 60 m.cum. of water for water supply to the district of Ostravice. The project was planned as early as 1918, but was constructed only during 1965-69. The maximum height of the dam is 65 m. The salient features of the project are :-

i) Hydrology

Catchment area	146.35 sq.km.
Average rainfall	1203 mm.
Average annual flow	3.11 cum/sec.
Minimum flow	0.120 cu.m./sec.

ii) Reservoir

Gross storage	59.8 M.cum.
Live storage	46.8 m.cum.
Dead storage	2.5 m.cum.
Reservoir area	324 Hectares.

iii) Dam

Maximum height	65m
Crest length	342 m.
Total volume	1.34 m.cum.

Geology

The dam site and reservoir lie in Godulian layers of Carpathian Flysch. The river gorge at the dam site is very narrow having a bottom width of 140 m with steep abutment. The substrata consists of sand stone and of clayey shales, and these are inclined at 15° to the axis of dam dip being 23° to 30° upstream. The main direction of cracks is normal to the direction of the layers and at the dam site there are several fault zones. The valley is filled with the alluvial river sediments consisting mostly of gravel and sand of thickness 2-6 m. In the reservoir area, there are

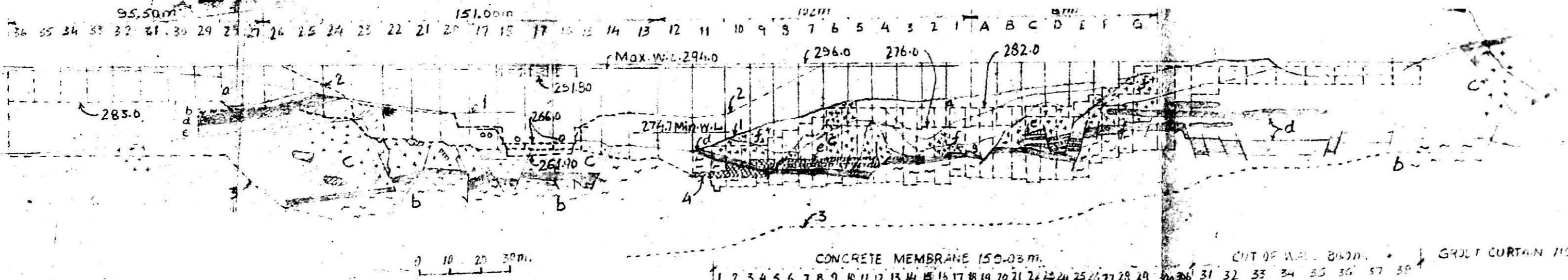
possibilities of land slides occurring mainly on the Recica brook valley on the right and on the Cstravice river valley on the left.

The layout of the project is shown in figure 5. On the right side of the inlet and outlet tunnels are located with intake towers as also the spillway with a chute over the tunnels discharging into a common stilling basin. The outlet tunnel is 3 m. in dia, and 290 m long, designed for a discharge of 70 cum/sec. and the intake tunnel is 2 m. in dia and 319 m. long and capacity 42 cum/sec. spillway is 19.4 m long and has a capacity of 73.5 cum/sec. The chute 6.5 m. wide and 172 m. long ends in the form of a ski-jump platform with baffles.

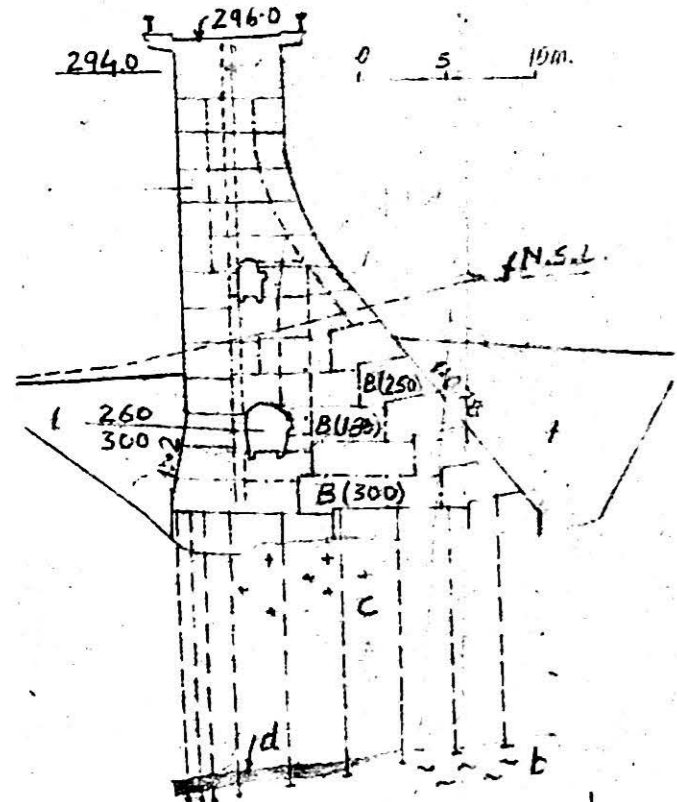
The typical section of the dam is shown in figure 5. The dam is of the sloping core type consisting of an impervious core of loam materials and outer zones of rockfill. A transition layer of gravel is kept on the U/S side where as a sand filter and a gravel zone are kept on the downstream side. A zone of random material is introduced on the d/s between the transition and rockfill zones.

Typical grading curves of materials are shown in fig.6. The material of the core is mostly of CL type with density 1.68 to 1.92 tons/cum. C.M.C. 14.5% to 20% shear parameters $\phi=26^{\circ}$ - 50° and $C=0.17$ kg/sq.cm. Permeability = 1.3×10^{-7} cum/sec. Filter sand was SP type material. Material of gravel zone was of GW, GM, GC, type, density, 2.06 to 2.2 tons/cum. and shear strength $\phi=38^{\circ}$. Rockfill material was quarried sandstone of compressive strength 908-1280 kg/sq.cm.SP. Gravity 2.62 to 2.68 and shear strength $\phi=43^{\circ}$.

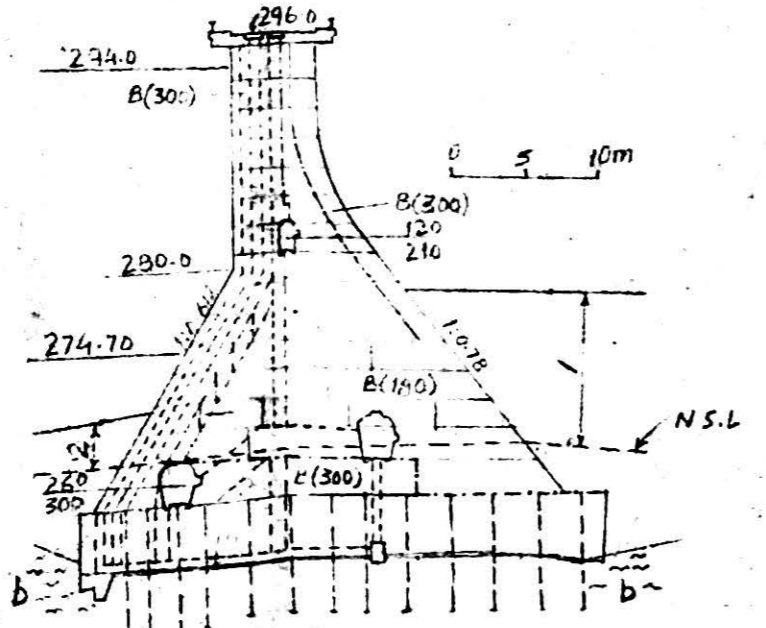
The impervious core of the dam is connected to the bed rock through a grouting gallery and a levelled concrete lift. The foundation rock was grouted with cement. About 21000 metres, holes were drilled. Cement consumption was of the order of 150 kg. drill hole meter. Grouting pressures upto 40 atm were used. During grouting the effect of blasting on the grout curtain was also studied and it was found that it was quite safe to build the grout curtain under the dam before blasting the rock for the grouting gallery foundation.



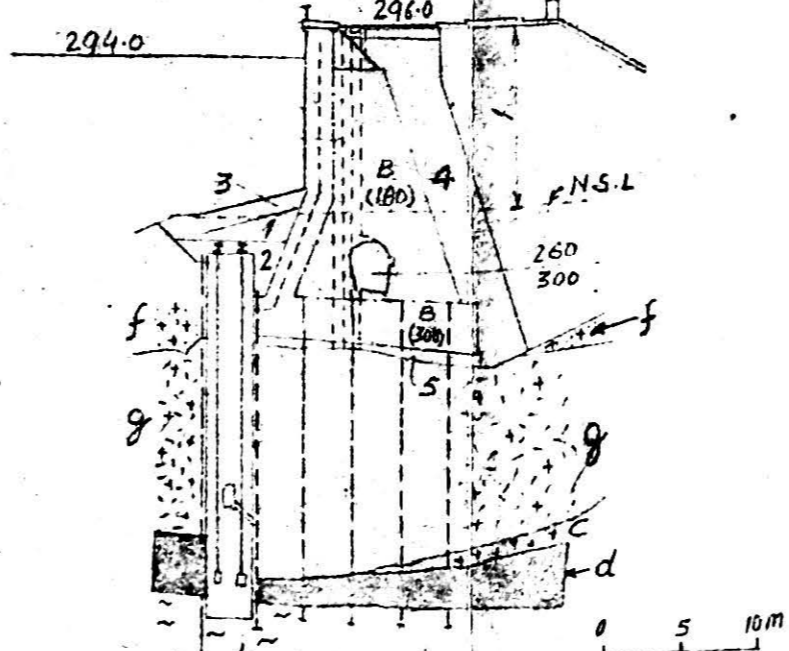
GEOLOGICAL SECTION IN THE AXIS OF DAM. a-LOAM, b-CLAYEY SHALE, c-TESCHENITE, d-DARK CONTACTS, e-LIGHT CONTACTS, f-DECOMPOSED TESCHENITE, g-WEATHERED TESCHENITE, 1-ORIGINAL GROUND SURFACE, 2-ADAPTED GROUND SURFACE AT U/S TOE OF DAM, 3-DEPTH OF GROUT CURTAIN, 4-CONCRETE PLUGS.



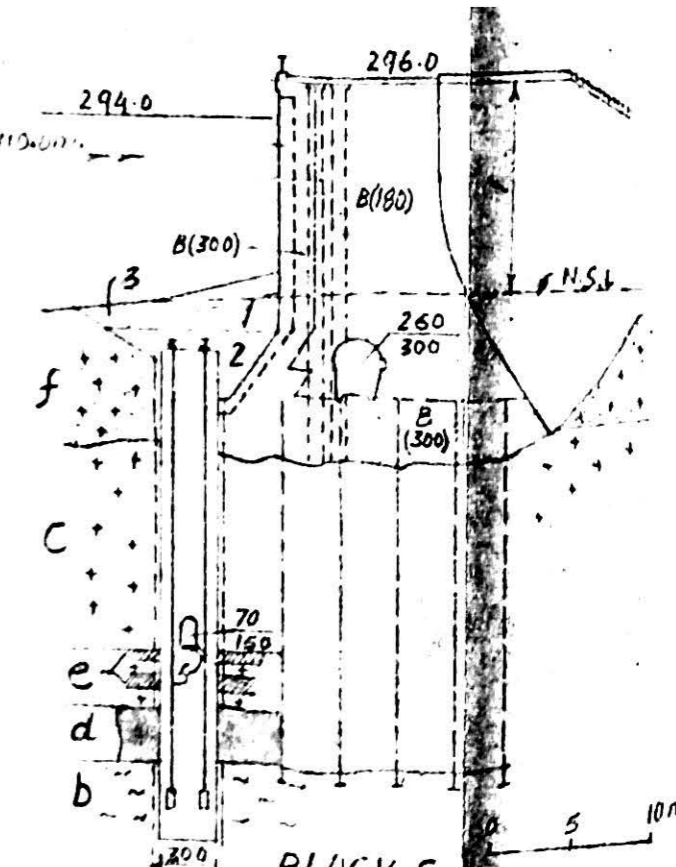
BLOCK-1
 1-Compacted unsorted earth;
 b-clay shale; c-Teschenite;
 d-Dark contacts.



BLOCK-13
 1-Compacted unsorted material;
 2-Compacted loam; b-clay shale.



BLOCK-4
 1-Compacted unsorted earth (overburden from stone quarry);
 2-Compacted loam; 3-Pipran; 4-Compacted rock fill; 5-Concrete base lift; b-Clay shale; c-Teschenite; d-Dark contacts; f-Decomposed teschenite; g-Weathered teschenite.



BLOCK-6
 1-Compacted unsorted earth (overburden from stone quarry);
 2-Compacted loam; 3-Pipran; b-clay shale; c-Teschenite;
 d-Dark contacts; e-light contacts; f-Decomposed teschenite.

FIG. 4 ZERMANICE PROJECT.

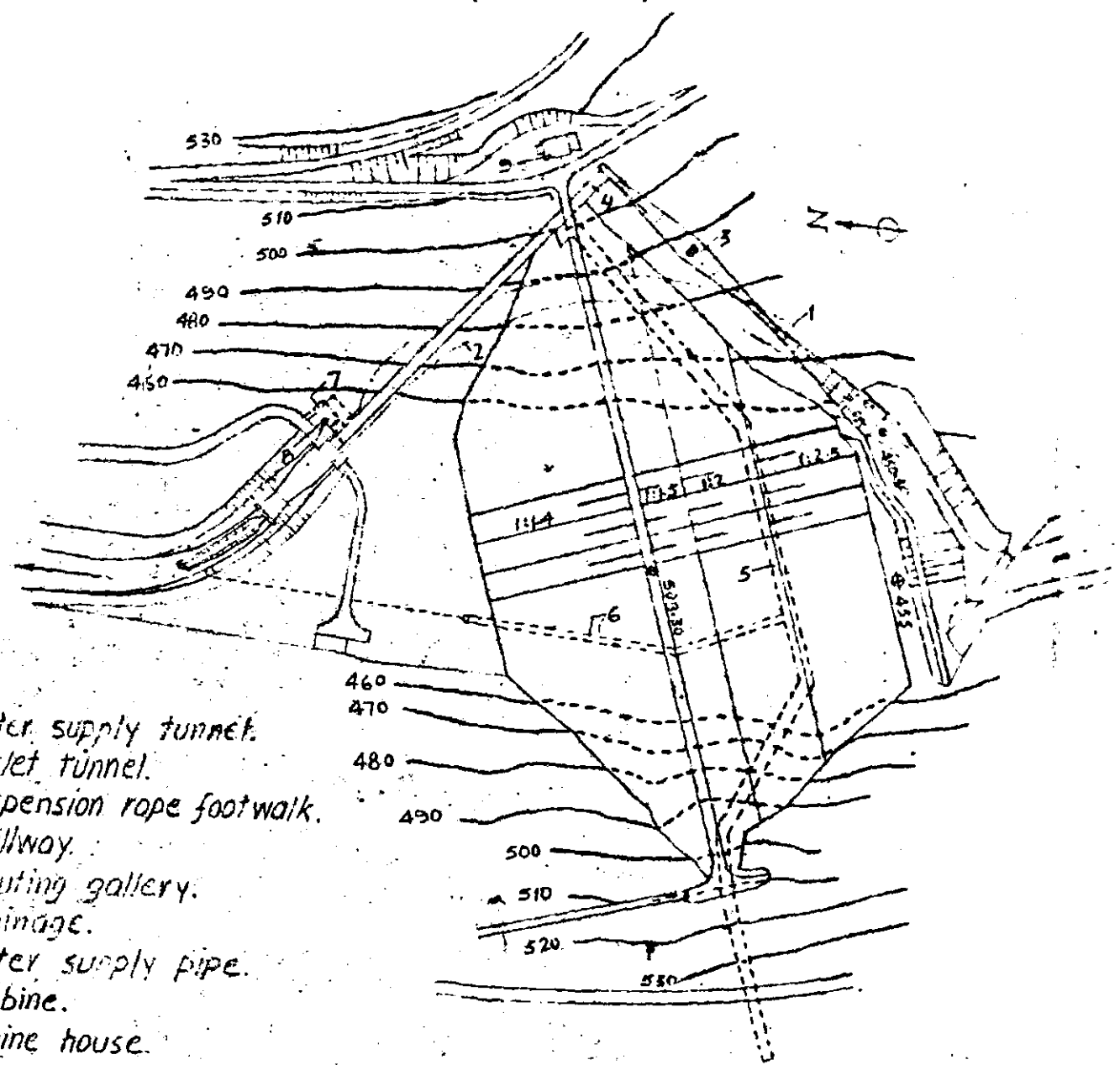
The interesting part of the design is the testing of the model of the dam for a possible overflow in the case of slides taking place into the reservoir. The other interesting aspect is the construction of the impervious core. The material is one of the borrow areas was found to have moisture contents upto 7% above the optimum values. To reduce the moisture content of the material, deep drainage trenches were dug and this resulted in an average reduction of moisture content of about 2%. This operation was done well in advance of the beginning of exploitation of the borrow area. In addition a drying plant consisting of a rotary kiln of 2 m. dia and 14 m. long with supply line of hot air from high efficient burners and a system of feeders and conveyor belts were installed at the dam.

INSTRUMENTATION

To study the behaviour of the dam, instruments have been installed to observe settlement, pore pressure in the impervious core, quantity of seepage and earth pressure on concrete structures. Four telescopic cross arms and sixteen alti-meters are installed for measuring settlements. The deformations are also measured at seventeen control points on the downstream slope. Precise levelling and trigonometric surveying are carried out periodically to measure vertical and horizontal deformations. Horizontal displacements are measured with a steel rope running from the alti-meters to measuring shafts. Pore pressure are measured with double tube piezometers tips at the selected points. Seepage to the foundation is measured at the outlet of the drain into the drainage gallery. Earth pressure is measured with the help of pressure cells installed on the back of drainage gallery of one cross section.

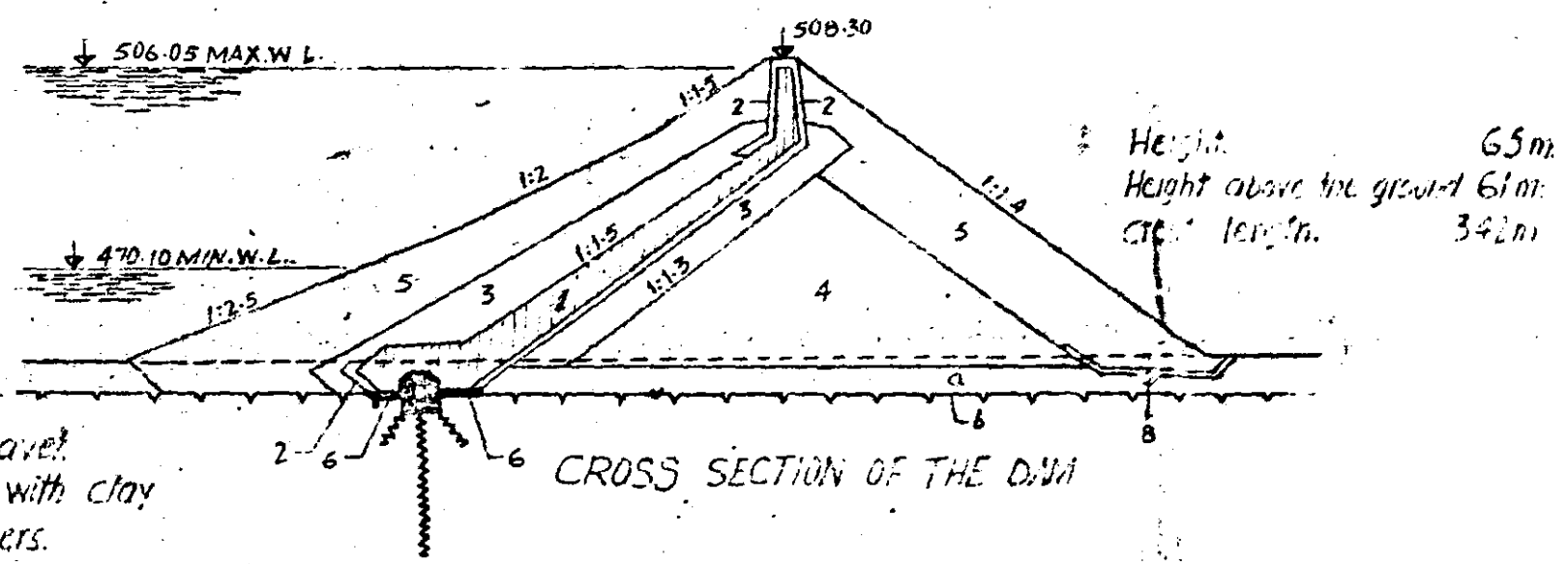
131. NOSICE HYDRO PROJECT

Nosice Dam is one of the highest dams constructed on Vah river cascade. The cascade is intended to develop water supply, flood control in upper reaches, irrigation of lower part of catchment area, to increase navigability of river and to develop power. It is expected that on completion of Vah river cascade a 278 km. long water way will be created to cater for 1000 ton ships. It is also proposed to construct 25 power stations on the river with a total installed capacity of about 1000 MW.



- 1. Water supply tunnel.
- 2. Outlet tunnel.
- 3. Suspension rope footwalk.
- 4. Spillway.
- 5. Grouting gallery.
- 6. Drainage.
- 7. Water supply pipe.
- 8. Turbine.
- 9. Engine house.

SITE PLAN OF THE DAM
(SANCE PROJECT)

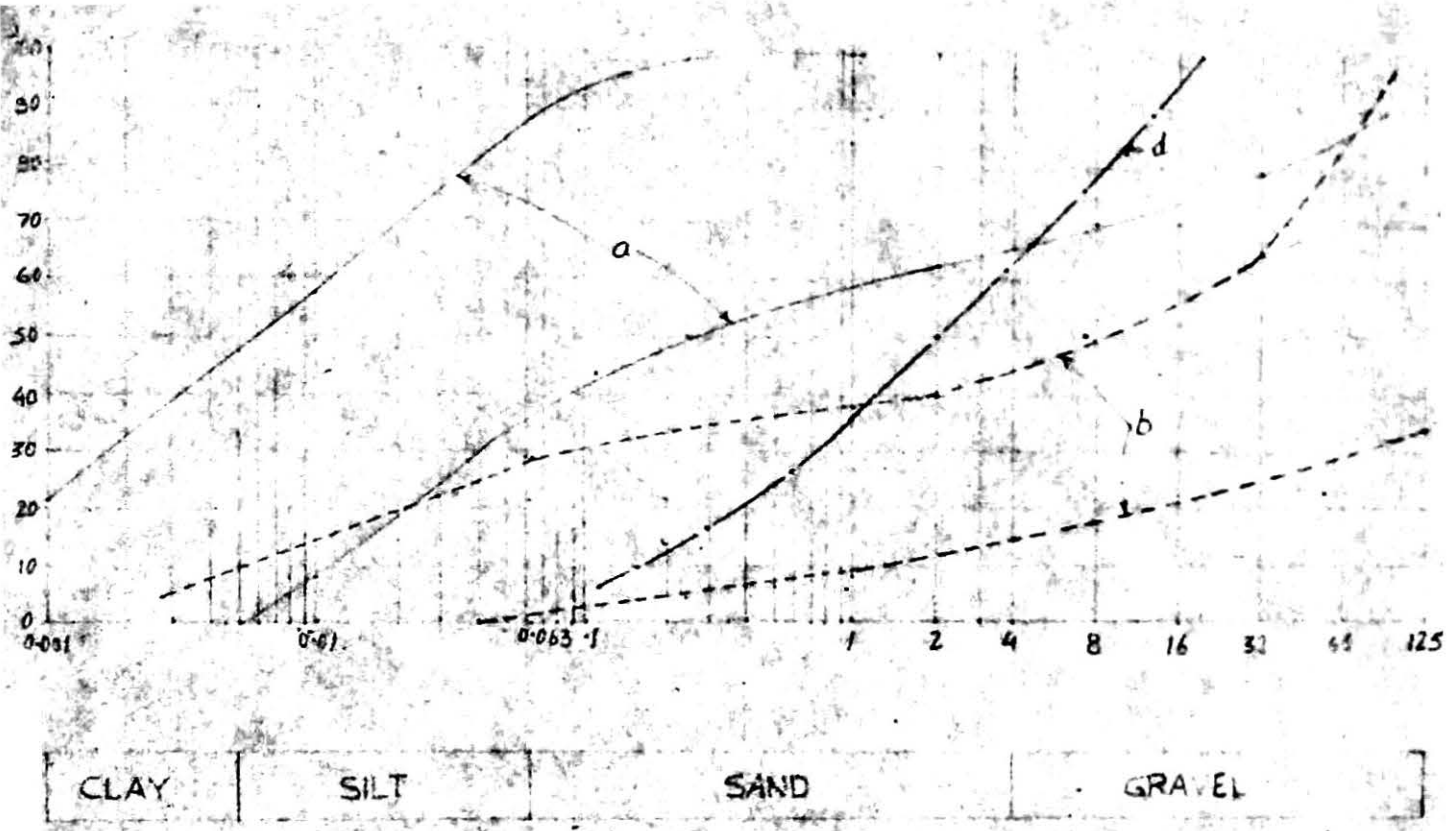


Height 65m.
Height above the ground 61m.
Crest length 342m

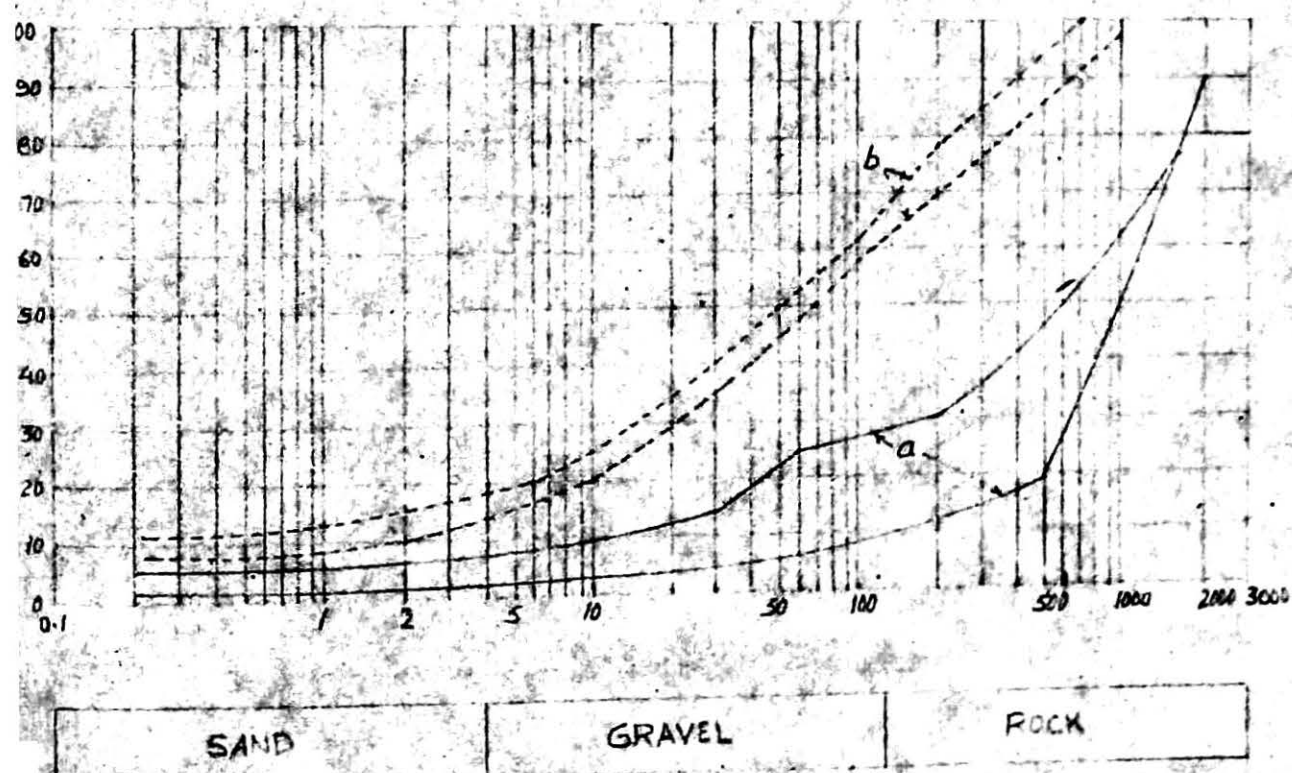
- a. Alluvial gravel.
- b. Sandstone with clay shale layers.
- 1. Loam
- 2. Filter.
- 3. Gravel from Ruzance borrow pit.
- 4. Gravel and debris from Ruzance with assorted quarry stone.

- CROSS SECTION OF THE DAM
- 5. Compacted quarry stone (sandstone)
 - 6. Concrete.
 - 8. Drain.

FIG. 5



Grain size curves: -a- Loams from velky potok borrow pit.
 b- Gravel from ruzanec borrow pit.
 d- Filter.



Grain size curves of the rockfill: -a- Selected rockfill.
 b- Quarry run rockfill.

Geology at the dam site is not favourable and varies from one end to other end of dam. The right abutment consists of subsoil composed of marly rock in the centre sandstone and layers of slate below outlet structure is met with. Marl extends below power house blocks and left abutment consists of Conglomerates. The dam is designed in such a way that all the block rest on the same type of rock. Salient features of the project are :-

Hydrology

Catchment area	7895 km ²
Annual precipitation	980 mm.
Average discharge	133 cumecs.
Minimum discharge	19.2 cumecs.
1 in 100 years flood	2500 cumecs.

Reservoir

Reservoir area	5.7 Km ²
Length	12 km
Storage capacity	36 million cum.
M.W.L.	280 m.

Dam

Type	Concrete gravity dam.
Maximum height above foundation level.	40 m.
Length	475 m. consists of 31 block 6.5 to 16 m. wide.
Top width	7.75 m.
Spillway	5 bays of 17.3 x 3.5 m. controlled by flap gates.
Maximum capacity	1200 cumecs.
River sluices	5 of 12 x 4.8 m. Controlled by sector gates to control passage of sediment, ice and floods.
Maximum capacity	3500 cumecs.
Fish ladder	Provided in one block of dam consists of a chamber of 13.95 m level difference and 9 fish lift of 10.95 m.

Power Plant (Fig.7)

Type of turbine	Kaplan
No. and size of Unit	3 of 22.5 MW each.
Maximum head	22.5 m.
Minimum head	11.5 m.
Discharge/unit	130 cumecs.

Tail Race Canal

Length	2.65 km.
Discharge capacity	400 cumecs.
Section of canal	Trapezoidal
Base width of canal	48 m.
Depth of flow	varies from 3.5 m to 6 m depending on discharge.

The construction of Project started in 1949 and 1st Unit was commissioned on 1st September, 1957. The work involved 300 thousand cum. of concrete, 7.6 million cum earth work and 310 thousand cum excavation.

Special features

Protection of foundation against the action of mineral water. The mineral water was continuously pumped out of injection of clay in suspension with chemical admixtures. The foundation was isolated by Basalt Cubes placed into mortar prepared with basalt sand and trass cement and filling the joints with asphalt.

iv. ZELIVKA WATER SUPPLY SCHEME

The scheme is intended to meet the increasing demand for drinking water to Prague and other nearby regions. The project is proposed to be built in stages to meet the increase in requirements of water.

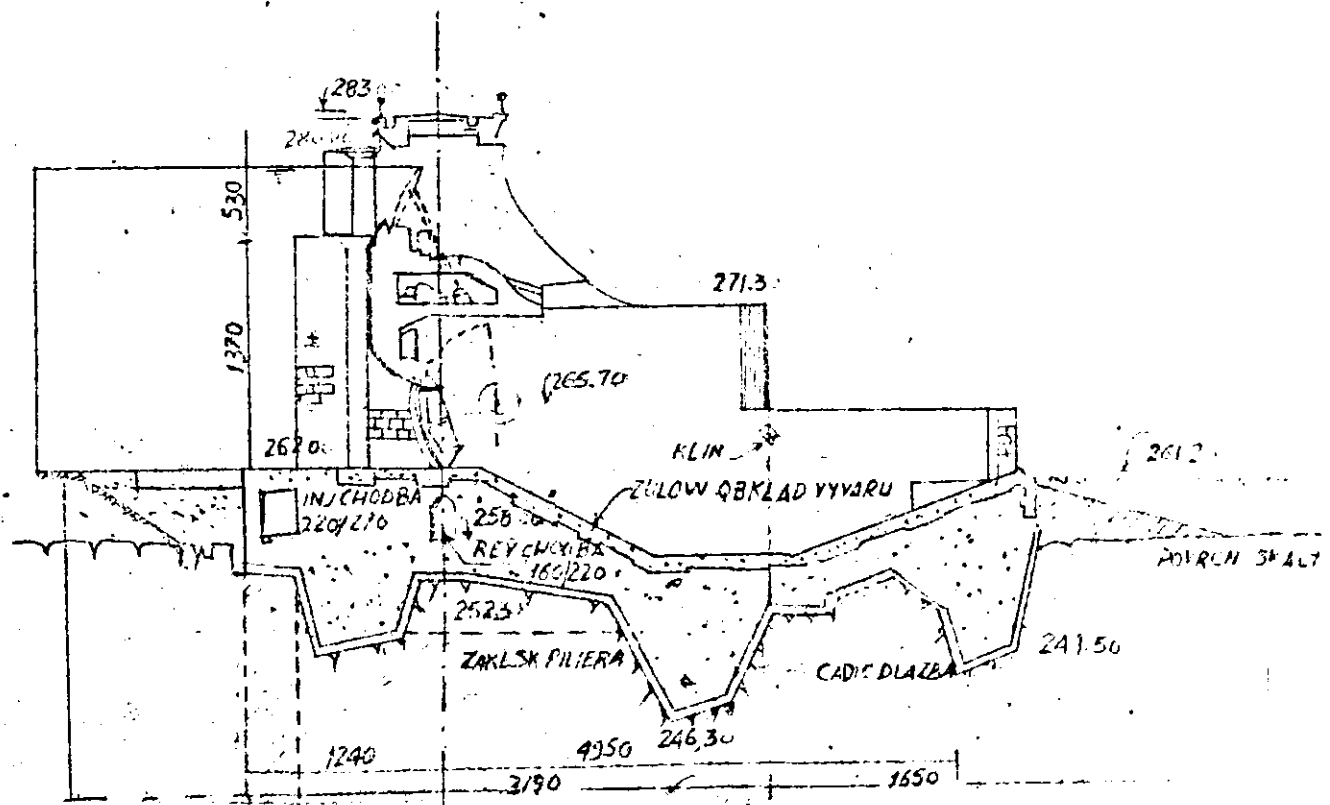
The project envisages the construction of a dam across the river Zelivka a tributary of Valtava. The foundation conditions as well as availability of suitable construction materials indicated that the earthfill dam is the most suitable type and this was also suitable for construction in stages. The salient features of the project are :-

Hydrology

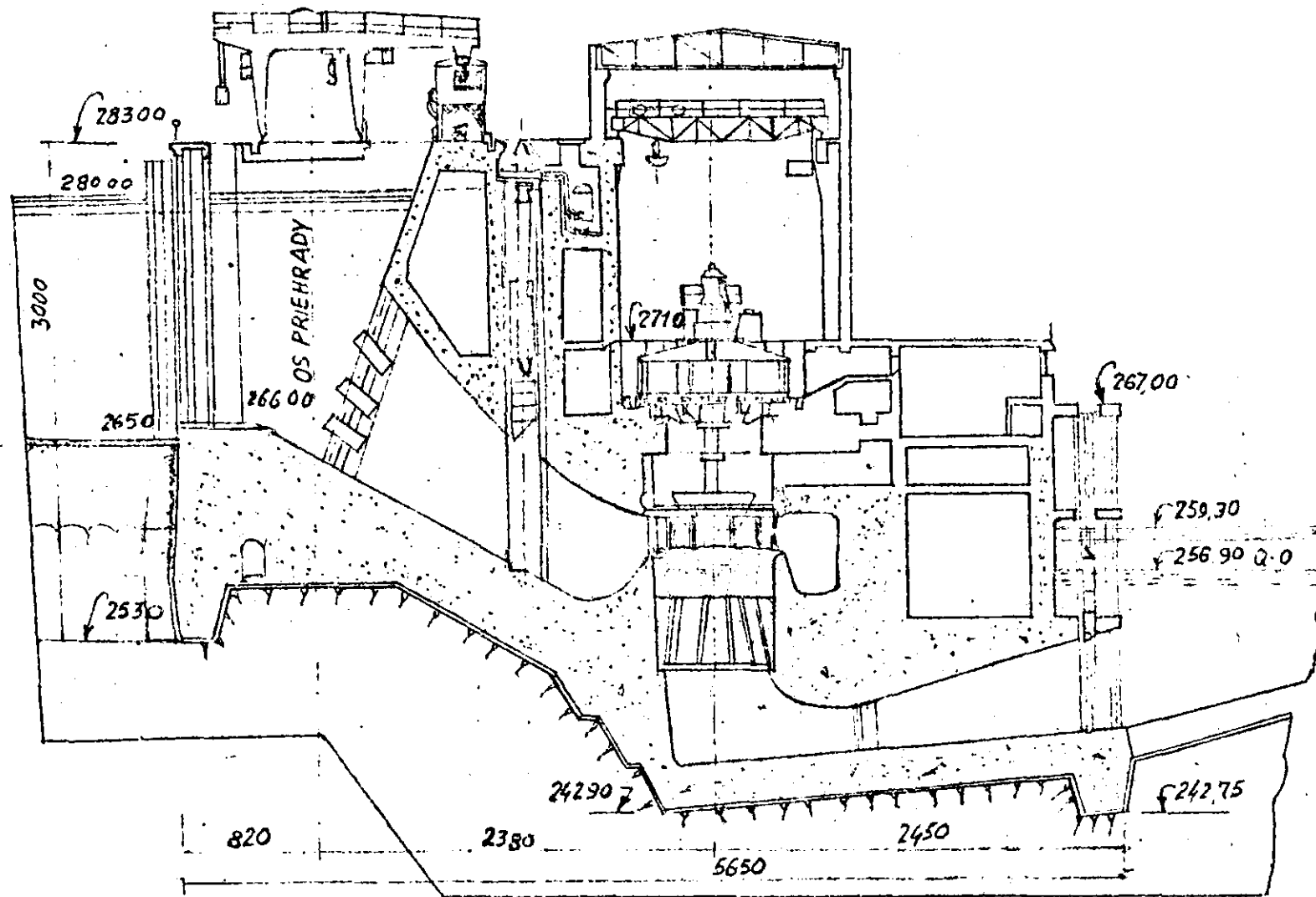
Catchment area	1178 sq./km.
Average annual rainfall.	674 mm.
Average discharge	7082 m ³ /sec.
Minimum discharge	308 m ³ /sec.

Reservoir

	<u>Stage I</u>	<u>Stage II</u>
Gross storage	80 m.cum.	264 m.cum.
Live storage	66 -do-	246 -do-
Dead storage	14 -do-	18 -do-
Reservoir area	613 ha.	1462 ha.



NOSICE PROJECT
CROSS SECTION OF THE OUTLET
FIG. 7 (a)



NOSICE PROJECT
CROSS SECTION OF THE POWER PLANT. FIG. 7(b)

RESERVOIR

<u>Dam</u>	<u>Stage I</u>	<u>Stage II</u>
Maximum height	40 m	58 m.
Crest length	385 m	620 m.
Total volume	1056060 cum	2056000 cum.

The dam is of the sloping core type consisting of an impervious core which is proposed to be raised in the second stage (fig.8). The spillway is of the morning glory type. The first stage spillway is proposed to be raised along with the approach bridge. The space between the second stage and the first stage spillway is proposed to be plugged with concrete.

Y. SLAPY PROJECT

Slapy project is the 2nd largest on Vltava river downstream of Orlik Project.

Geology

The bed rock in the whole area of the dam foundation is formed by amphibolitic rock formation with slight foliation. These rocks are very hard and tough and available at depth of 2 m. in valley. The strike of foliation is perpendicular to the direction of valley which is favourable for the situation of dam.

Salient features of the project are :-

Hydrology

Catchment area	12982.7 sq.km.
Annual rainfall	682 mm.
Normal discharge	84.5 cumecs.
1 in 100 years flood	237.4 cumecs.

Reservoir

Length of reservoir	44 km.
Storage capacity	200 million cum
M.W.L.	271.00 m
Min. W.L.	247.00 m.

Dam

Type of dam	Concrete gravity dam
Height	65.0 m.
Length	260 m.

Spillway	4 bays of 15.0 x 8 m. controlled by radial gates.
Spillway capacity	3000 cumecs.
River outlets	2 of 4.0 m. controlled by hollow jet valves on d/s.
Capacity	360 cumecs.
Penstocks	3 of 5.0 m diameter steel penstocks embedded in spillway block.

Power Plant (fig.9)

Power plant is located below spillway-structure, which forms the roof of power house.

Type of turbine	Kaplan turbine.
No. and size of units	3 of 48 MW each.
Discharge/unit	100 cumecs.
Maximum head	56 m.
Minimum head	53.4 m.
Normal head	51.4 m.
Overhead crane capacity	2 of 125 tons each.

Navigation Lock

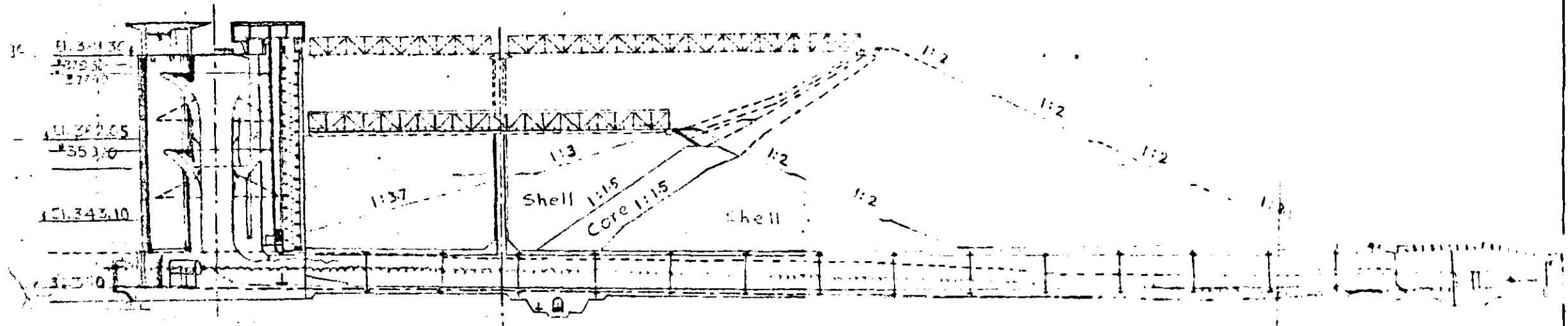
Facility for navigation upto 300 tons is proposed. A 6.35 x 33.0 m navigation lock is provided for a lift of 6 m.

Construction stage

The river gorge was blocked by coffer dams on u/s and d/s. The water were diverted through the tunnel in right abutment.

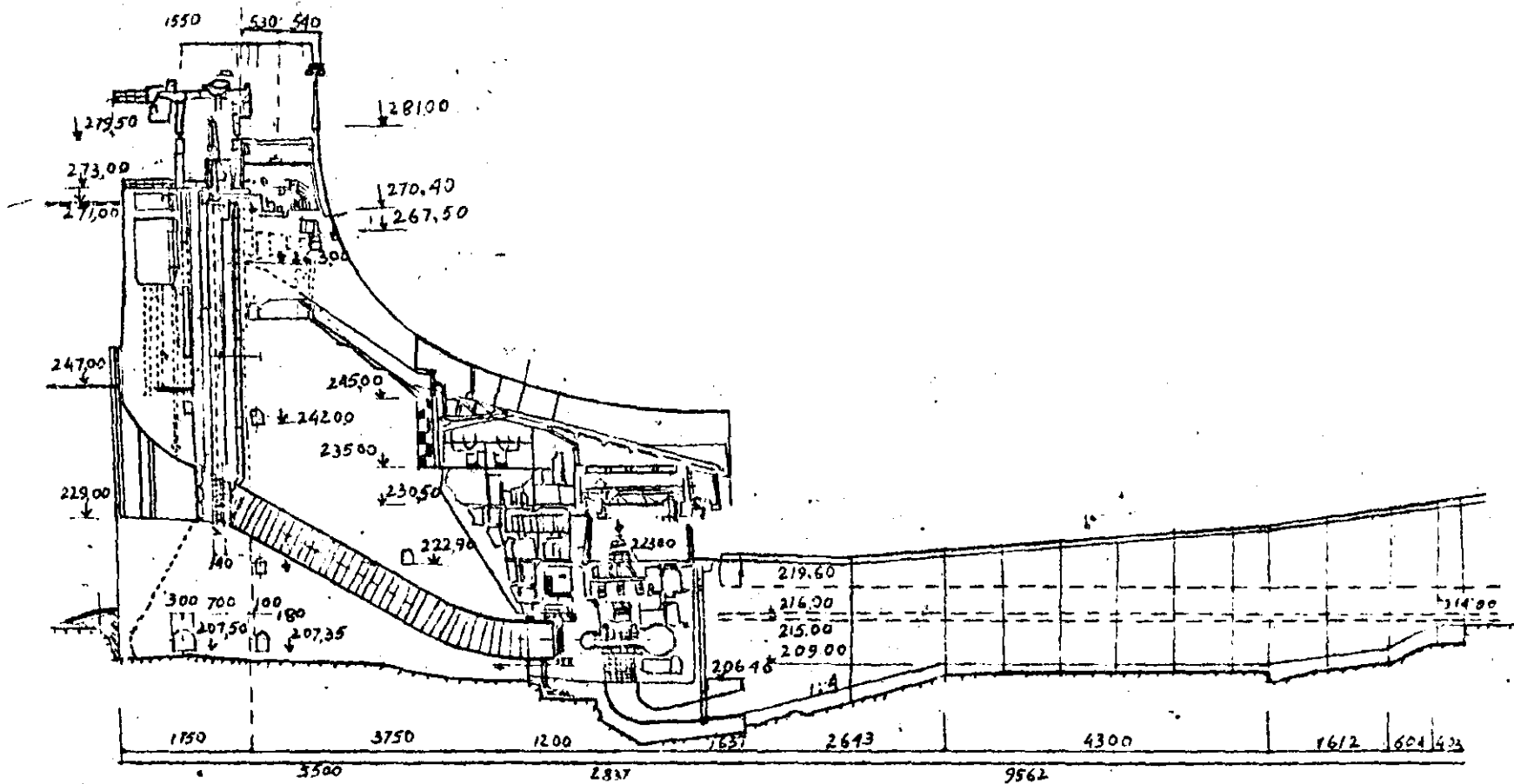
The upstream coffer dam 157 m long was rockfill dam with concrete core resting on six steel caissons. The centre part of coffer dam about 18 m. long was over flow type with crest paved and upstream face reinforced by wire stone mattress. It was designed for a 3.5 year flood.

The d/s coffer dam was also of same type of about 8 m height. The diversion tunnel was horse-shoe shaped of size 10 m x 12 m height and 360 m long and was bricklined.



ZELIVKA DAM

FIG. 8



CROSS SECTION OF DAM
RENSTOCK AND POWER PLANT

SLAPY PROJECT FIG. 3

The construction of diversion work started in July, 1949 and river diverted in February, 1951 and coffer dams in May, 1951. The construction work of dam and power plant started in May, 1952 and completed in 1955-56. The first unit commissioned in October, 1955.

Special features

The design and layout of overflow power plant is a unique feature of project. At the construction of power plant the various methods for speedy construction and erection in power plant as described for Crlik power house were first developed. The diversion tunnel was closed by a reinforced concrete block floated down to tunnel intake face.

vi. CRLIK DAM PROJECT

The Crlik dam is located 87 Km. upstream of Prague on river Vltava. It is the highest dam forming largest reservoir in the Vltava valley.

Geology

The foundation of the dam consists of schist formation by dykes of lamprophyres. The side slopes are covered with 10 m thick overburden consisting of bouldery debris. The left abutment is susceptible to rock slides. Salient features of the project are :-

Hydrology (below confluence of Otava)

Catchment area	11986 sq.km.
Average annual rainfall	690 mm.
Average discharge	82.2 cumecs. -
1 in 100 year flood	2290 cumecs.

Reservoir

Area of reservoir	2.64 hectares..
Length of reservoir	70 km.
Storage capacity	704 million cum.
M.W.L.	354.00
F.R.L.	351.60
Min., W.L.	330.00

Dam

Type of dam	Concrete gravity dam.
Height	91.5 m. high
Length	450 m. long
Quantity of concrete	1050,000 cum. (33 blocks of 15-16 m wide)

Spillway	3 bays of 15 x 18 m. controlled by radial gate.
Discharge capacity	2184 cumecs.
River outlets	2 of 4.00 m (dia. steel) pipe controlled by hallow valves on d/s.
Capacity	371 cumecs.
Penstocks	4 of 5.250 m. dia steel penstocks embedded in dam. Thickness of lining 20-35.

Power Plant

Fig 10

Located at the toe of the dam.

Type of turbine	Kaplan Turbine
No. and size of units	4 of 94 MW each.
Maximum head	71.5 m.
Normal head	69.10 m.
Minimum head	45.0 m.
Crane capacity	2 of 250 tons.

Navigation lock

Facility for transporting 300 ton ships by inclined ship lift drawn by Electric cart. *Fig 11*

The construction of the project was taken up in the year 1954 and the 1st unit was commissioned in April, 1961. During the 1st stage, the coffer-dam was constructed to work on portions of dam on right bank and construction of diversion channel and 2 tunnels opening of 7.5 x 5 m. in the monoliths for outlets. In the 2nd stage when river is diverted through these tunnels in Feb. 1958, the power dam and power house were completed. Cofferdams were designed for 1 in 100 year flood.

Special features

The speedy construction of power plant was achieved by :-

- 1) Eliminating the unfavourable effects of heat of hydration of mass concrete without artificial cooling by the use of fly ash.

FIG. 10

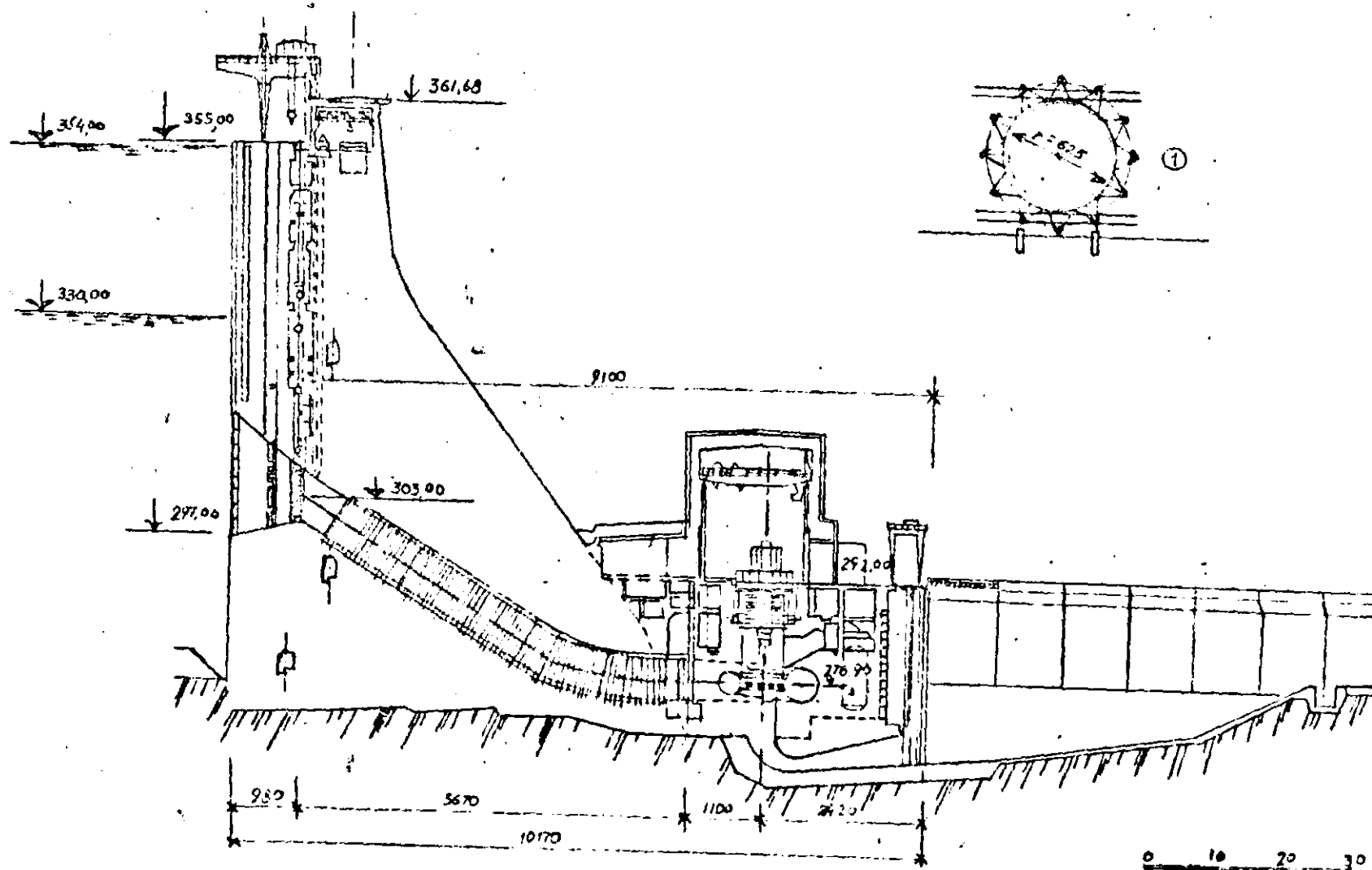
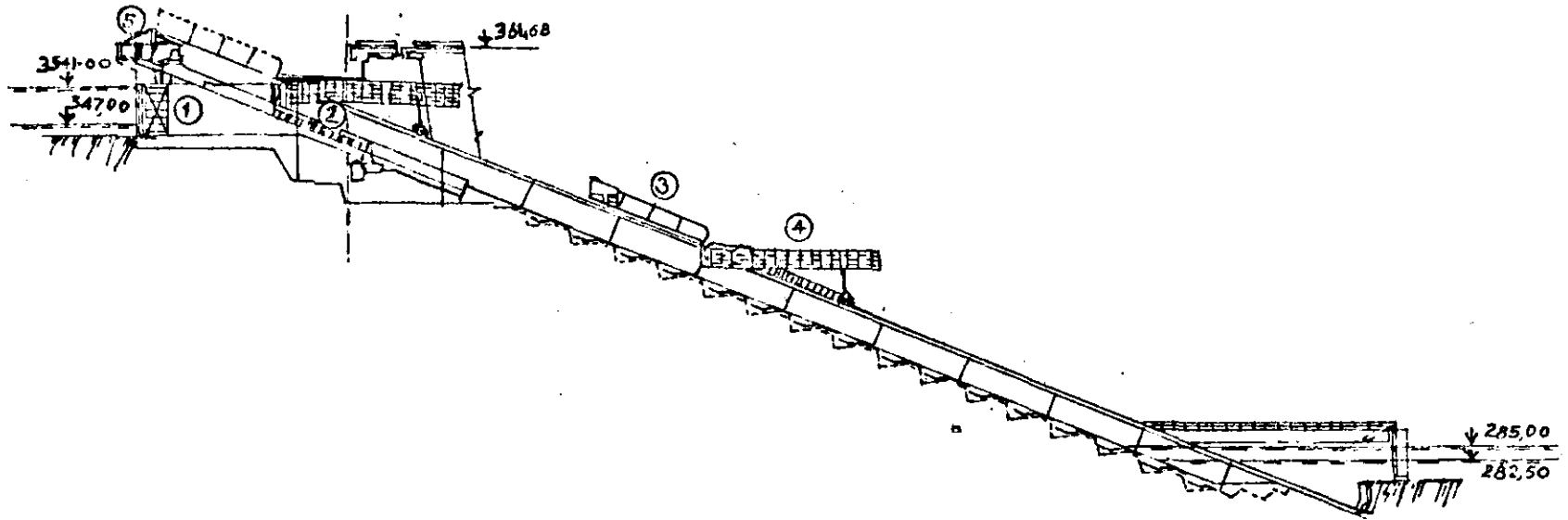


fig. no.

CROSS SECTION THROUGH DAM AND BOTTOM
OUTLET, SPILLWAY STRUCTURE AND STILLING BASIN

ORLIK PROJECT FIG. 10



1. strutting gate
2. the inclined gate
3. electric pull truck.
4. steel tank
5. hoist engine tank

FIG:II ORLIK PROJECT
NAVIGATION FACILITIES

2. The use of fully mechanised and automatised production of concrete by continuous process that of handling and transport.
3. Formation of welded reinforcements cages into units weighting upto 20 tons.
4. By extensive use of pre-fabricated concrete structures and reinforced concrete facing instead of usual shuttering.

The downstream wall of power plant and piers between d-raft tubes were lined with 10 cm thick reinforced concrete panels wedded to reinforcement and Vieren del prefabricates 13 m. long 1 m. thick and 1.11 m. high, which were placed on top of each other. The hallows were then concreted. This speeded up and simplified the construction of sub-structure concrete of power plant and also gave a saving in wood for shutterings. However, the use of pre-fabricates made it essential to establish a factory at site.

5. The super structure consists of steel structure, the assembly of these were made by cable way crane with a lifting capacity of 20 tons. The erection of the super-structure frame took 2 days for each unit block.
6. The walls are of pre-fabricated concrete panels fitted to steel structure by special clips. The joints were sealed with hard rubber in a PVC cover.

With above methods, it was possible to put the first turbine into operation 28 months after the concreting of power house was taken up.

vii. MECHANICAL PROJECT

This is an earth dam across the river Ohre a tributary of Labe to store 290 m.cu.m. of water for watersupply and power generation. The foundations conditions existing at the dam site consisted of a top layer of clay of about 15-20 m. thickness underlain by sand. Thin lenses of sand were also found at different places. The maximum height of the dam is 54.5 and length 3280 m. In view of the low strength of the foundation material the slopes of the dam on both upstream and downstream sides are very flat. The dam section is a zones one consisting of impervious core with casing zones on both upstream and downstream sides.

To facilitate drainage of the sand lenses, two rows of relief wells are provided on the downstream side. Typical section of the dam is shown in fig. 19.

5.3 OBSERVATIONS

It is of interest to note that in Poland and Czechoslovakia projects are planned on each river system; basin-wise plans are prepared to obtain the most optimum utilisation of water resources. This method of study of the entire basin and planning the projects would lead to most economical exploitation of utilisable energy. In our country the selection of projects are made not on the entire basin but arbitrarily depending on the demands of the regions.

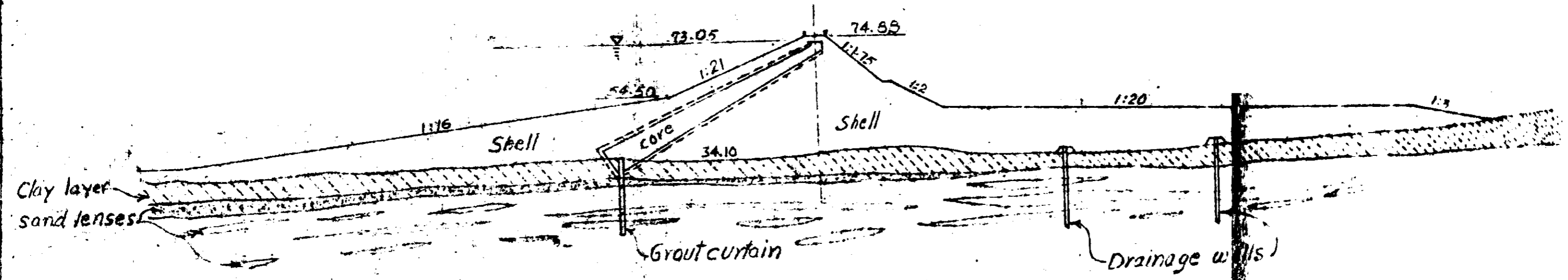
In Poland, river Vistula has been planned systematically utilising the entire basin. Similarly, plans are being made for developing Odra river. Separate organisations are set up to work out the plans and fix up priorities for execution to obtain the maximum benefits with the minimum of investment in the shortest possible time. In the case of Czechoslovakia, river Valtva and river Vah have been planned systematically and the projects in these river basins are being undertaken for execution in a phased manner. It is most essential to complete the investigations of the river basins to obtain most economical projects.

Whenever the projects are undertaken for execution, the attention is fixed on the method of accelerating the speed of construction. In order to achieve this objective scientific studies are undertaken during the period of construction. Some of the examples are illustrative of such endeavours.

i. Whenever the power house is located at the toe of the dam, cableways are used for erection of draft tube liner, scroll case and penstocks without waiting for the erection of the overhead travelling cranes in the power house.

ii. The superstructure of the power house and the auxiliary rooms are designed with steel structure systems with pre-fabricated reinforced concrete panels which can be erected with these by the help of the cableways.

FIG. 12



NECHRANICE DAM. FIG. 12

iii. Pre-fabricated concrete elements are used to replace the form work in the construction of power house and other ancillary works.

iv. Submergence of land and protection of monuments are given due consideration in planning reservoir projects. In fact, they prefer to have a series of low dam with power houses instead of concentrating on high dams which may result in submergence of vast areas.

v. Extensive model studies are carried out for solving complex hydraulic and structural problems to arrive at an economical solution. It may be of interest to note that in the case of Sance dam project, hydraulic model studies were done to find out the effect of possible overflow over the completed earth dam in case the adjacent unstable hills slide into the reservoir.

vi. Instrumentation of major structures has become a regular feature particularly earth dams. Systematic records of observations are maintained and periodical analysis of the observed data is also undertaken. This will lead to economical designs as more scientific approach for the designs could be derived from these observations.

vii. At Sance dam in Czechoslovakia where material from the borrow area for construction of the earth dam was found to have moisture content about 7 per cent above the o.m.c., it was decided to reduce the moisture content by installing a drying plant consisting of 2 m. diameter and 14 m. long with supply line of hot air from high efficiency burners and a system of conveyor belts. This method was obviously working out very expensive. As such, they resorted to provide a systematic net work of drainage system by constructing drainage trenches and reduce the moisture content to within the acceptable limit.

viii. In the case of Zelvika dam in Czechoslovakia another interesting feature was observed. An earth dam of sloping core with an ultimate height of 58 m. was designed and planned to be constructed in stages viz. upto 40 m in the first stage and 58 m. in the second stage. The spillway consisting of morning glory hole was constructed to suit the first stage. In the meantime demand for water increased substantially. It was

decided to increase the height of the dam upto the full height in the first stage itself. As a result of this, the spillway had to be raised. This was done in a unique manner by constructing on the existing bell mouth of the spillway and raised it to the final height.

In Czechslovakia, there has been an interesting innovation in the hydro-electric field in the manufacture of uni-directional reversible turbines named HCNE after its inventors. These reversible turbines are used in power stations which have an auxiliary reservoir from where water is pumped back into the main reservoir during the idle hours of the power plant for production of power needed during the peak periods of the power system. The present reversible turbines revolve in one direction as a turbine plus alternator and in the opposite direction as a pump and a motor. The transition from one phase to the other takes place usually 4 times a day under normal conditions. The new Czechslovak invention is reported to eliminate the shortcomings during this transition stage and has a basic importance for the further development of hydro-electric power systems.

Thus, it can be observed that Poland and Czechslovakia who have launched extensive exploitation of its water resources, are proceeding in a more scientific and systematic way to obtain the optimum utilisation of its water resources. Though the dams are of medium height with a relatively small storage but all the designs and model studies are conducted in the laboratories to evolve most economical solutions.