

THE STORY OF THE HIRAKUD DAM PROJECT

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PREFACE

The story of the Hirakud Dam, the longest in the world, built entirely by Indian engineers, is a fascinating account of the victory of engineering over the twin scourges of mankind, famine and flood, that ravaged for ages the beautiful valley of the great river Mahanadi in Orissa, the abode of Lord Jagannath and the land of temples of great architectural and archaeological fame.

The Rs. 100 crore Hirakud Dam Project augurs for the inhabitants of the river basin a life of peace and plenty. The Mahanadi, known for its fury and devastation, has been befriended and harnessed in the service of man. Its enormous water wealth which was running waste will now bring new life to more than two and a half million acres of land and turn the wheels of industry, heralding a new era of progress and prosperity in the State of Orissa. Freed from the devastation of floods and the demoralisation that followed in its wake and assured of a perennial supply of irrigation water and large volume of power, the State can utilise her industrious and intelligent manpower to the optimum. The rich mineral and forest wealth can be fully exploited. The one-crop-a-year pattern of her agriculture will change to a highly diversified and productive one.

In writing the story of the Project it has by no means been an easy task to portray in advance the developments which are yet to take place but there has never been a moment of diffidence regarding the bright future that awaits the people of Orissa. In fact, the completion of the Project makes the beginning of the story of the great agricultural and industrial development in Orissa.

I am very grateful to Sri T. Sivasanker, I. C. S., Secretary to Government of India in the Ministry of Irrigation and Power, for having given me an opportunity to write the story of the first large multi-purpose river valley project on the Mahanadi. I am also very grateful to Sri M. S. Thirumale Iyengar, Chief Engineer of the Project and the officers and staff of the Project and of the Hirakud Land Organisation who spared no pains to bring me in close contact with every detail of the Project. I have drawn material for this publication freely from the published records of the Central and State Governments for which I am thankful to them. The chapter on Planning and Designs has been written with the help of information supplied by the Central Water and Power Commission. My special thanks are also due to Sri K. S. S. Murthy, Personal Assistant to the Chief Engineer, Sri G. K. Dogra, Under Secretary to the Government of India, Ministry of Irrigation and Power, Sri T. Chellaswami, former Statistician, and Sri Sivaram Singh the cinematographer of the Project. Wherever I have ventured an opinion, it has been entirely in my personal capacity.

The successful completion of the Project has inspired a new confidence in the greatness of India and in the skill of her engineers. They were confronted not only with complicated engineering problems involved in the construction of a project of such a gigantic magnitude but also of personnel management and human relations in dealing with a large task force consisting of skilled and unskilled workers whose total labour contribution exceeds 5.77 crores of man-days. Our engineers have done the job well and deserve the nation's gratitude.

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KANPUR



Foundation-Stone Laying Ceremony of Hirakud Dam by the Prime Minister—13th April 1948

CHAPTER I

A HISTORICAL RETROSPECT

Water is essential to life but in a wrong place and time it causes untold suffering and loss to man. Its absence in time of need results in drought. Floods and drought have ravaged the earth ever since man disturbed the natural balance of vegetation to satisfy the wants of his multiplying race. Since then he has had to wage constant war against both these scourges. The war is global. With indiscriminate destruction of forests and removal of the vegetation cover from the land's surface, damage by soil erosion has multiplied manifold. Rivers provided the most efficient natural system of drainage. But with land laid bare, the swift movement of rain water carries with it enormous quantities of earth. Due to silting, the river beds are constantly rising and this affects the natural capacity of rivers to discharge rain water thus exposing the vast areas of land and population in the valley to ever increasing danger of floods.

In Orissa, the frequent occurrence of floods and drought is responsible for disturbing the peaceful life of its people and upsetting its economy. One need hardly go back to remote history; the unprecedented floods in 1955 are still a recent memory. The State had experienced drought in the preceding two years. In the case of the Mahanadi, the problem is very complicated. The combined capacity of the many distributaries is much smaller than the capacity of the

main river, the difference being more than 25%. Further, the ridges between this river and the neighbouring river systems of Brahmini and Baitarni are low ; flood waters of these systems, therefore, spill into the Mahanadi, aggravating the flood situation in the Delta. The problem of floods in Orissa Delta has, therefore, naturally received considerable attention at the hands of experts and committees appointed from time to time. As early as 1858, Sir Arthur Cotton, one of the foremost pioneers of irrigation in India, suggested as a solution, the construction of weirs across the major rivers of Orissa, irrigation canals throughout the delta suitable for navigation and drainage channels between all irrigation channels and embankments. The Flood Enquiry Committee of 1927 did not favour the construction of flood control reservoirs on any of the rivers. They were opposed to embankments and suggested the opening of some of the estuaries to allow the free passage of floods into the sea.

It was in 1937 that Sir M. Visvesvaraya, a great planner of our times, emphasised investigating the feasibility of flood control reservoirs, especially on the Mahanadi. The Flood Enquiry Committee of 1938 advocated a limited policy of improvement of main rivers to ensure a freer flow of river discharges. For reasons of high cost, storage reservoirs were not recommended. The Committee, however, suggested a full investigation into the question of storage reservoirs after other cheaper methods had been tried and their results known and if it was found that the losses caused by floods justified the expenditure of a much larger amount on flood protection measures. Sir M. Visvesvaraya visited Orissa again in 1939. Although he was in favour of storage reservoirs in the upper reaches of the Mahanadi for flood protection, he recognised the difficulties of State boundaries and high cost. At that time, the numerous princely States had not been merged in Orissa and the basin-wide development of the Mahanadi involved the boundaries of a number of such States.

The Flood Enquiry Committee in 1940 laid special emphasis on embankments.

The problem was referred to the Government of India, in 1945 and was entrusted to the Central Water & Power Commission, then known as the Central Waterways, Irrigation & Navigation Commission. As a result of investigation at site, study of previous reports and discussions, a momentous decision was finally taken in favour of storage dams not only as a measure of protection against floods but also for conservation and utilization of the enormous water wealth of the Mahanadi for generation of power and expansion of irrigation facilities. The land transformation and revolutionary growth in economic activities in areas where such projects had been completed in other parts of the world, particularly in the Tennessee Valley, had succeeded in creating a more favourable atmosphere for the reception of such an idea than in 1937 when Sir Visvesvaraya first advocated it. Full harnessing of the Mahanadi and its basin-wide development required damming the river at three points, *viz.*, Hirakud, Tikkerpara and Naraj. But among the three sites, the decision was taken to proceed first with the construction of the dam at Hirakud in the upper basin of the river.

Investigations for the Hirakud Dam Project were undertaken by the Central Water & Power Commission before the end of 1945.

For a proper appreciation of the various features of the Project and its role in the economic upliftment of Orissa, it is essential to get a clear idea of the course of the Mahanadi and the nature and requirement of the land through which it flows. An account of the Mahanadi, therefore, precedes the description of the Project.

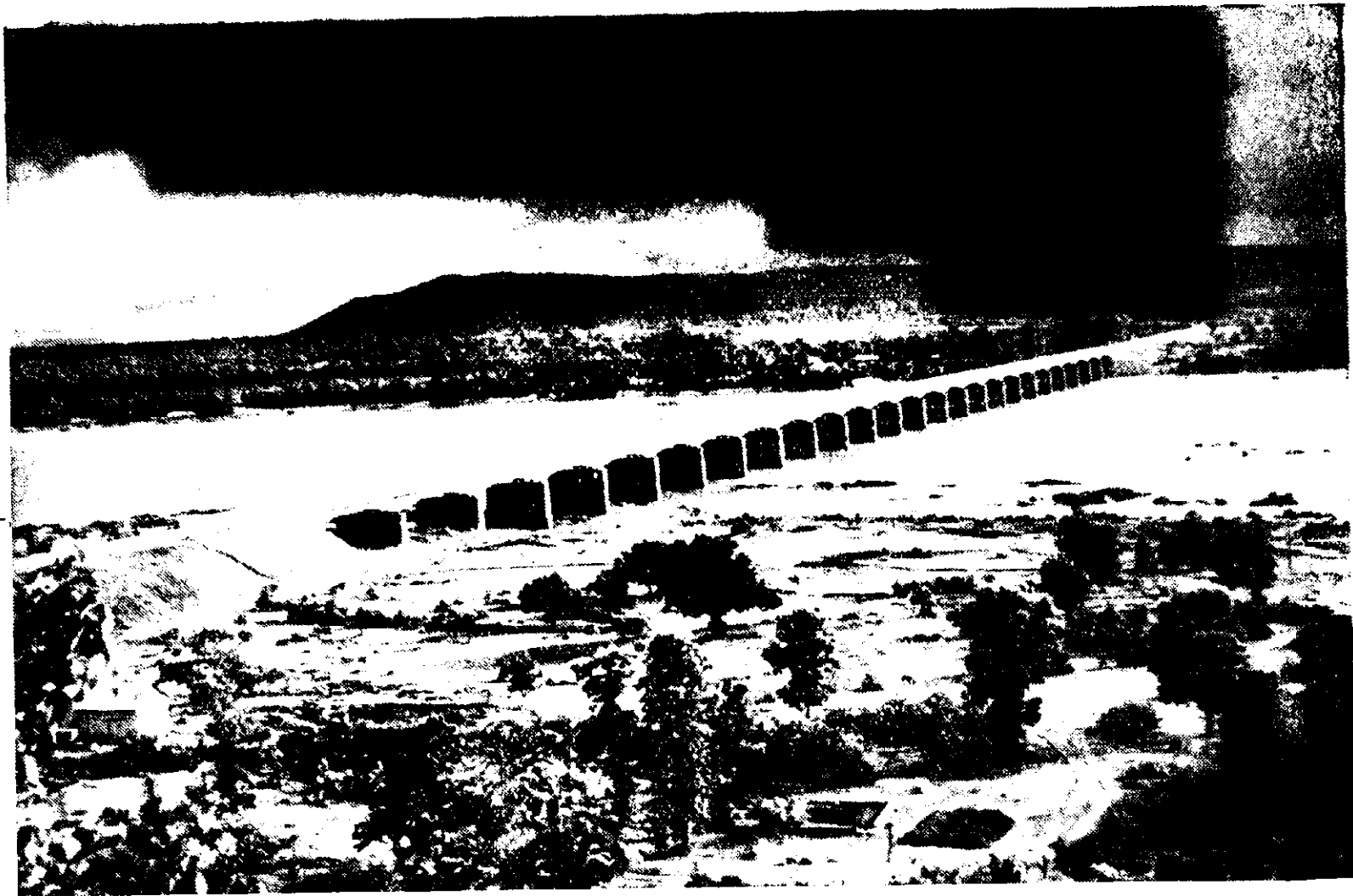
CHAPTER II

THE MIGHTY MAHANADI

Orissa is traversed by five rivers, i.e., the Mahanadi, the Brahmini, the Baitarni, the Burabalong and the Subarnrekha, the first three being the principal rivers. They all run parallel to each other and join the sea directly. Amongst them they carry 107 million acre ft. of water each year to the sea, a volume which will be more than thrice to fill Lake Mead, the biggest man-made lake in the world, formed by the Boulder Dam in U.S.A., with a capacity of 32 million acre feet. Hardly five per cent of this water wealth was being utilised so far and the rest ran to waste, threatening the lives and homes of people on its way.

The Mahanadi, true to its literal meaning, *viz.*, the 'Great River', is the largest of the three principal rivers. Its total length is 533 miles. It rises in the highlands of the Madhya Pradesh near Sihawa in the extreme south west of Raipur district. In the first part of its course, it flows to the north. On entering the Bilaspur district, it is joined by its first tributary, the Seonath. It flows in an easterly direction through Bilaspur, the other two principal tributaries that join it are the Jonk and the Hasdeo. It enters Orissa in Sambalpur district and turning south flows south and south-east through the district.

In Sambalpur, it becomes a major river with a width of more than a mile. Its tributaries here are the Ib, Org and Tel and numerous minor streams. It subsequently forms a series of rapids until it reaches Dholpur where the rapids end



Mahanadi Bridge

and the river rolls mightily towards the outermost line of the Eastern Ghats. The mountains of Eastern Ghats, rising slowly through a million years have left behind the Satkosia, a 14 mile wide gorge, through which the Mahanadi passes before fanning itself out in the plains of Cuttack. It enters the delta area of Orissa at Naraj between the two hills a mile apart, about 7 miles west of Cuttack. It further divides itself into two streams, viz., the Katjori and the Mahanadi, each branching-off again into many streams and traversing the Cuttack district from west to east, before the numerous channels fall into the Bay of Bengal near the False Point.

The river runs for the major part of its course in Orissa. Of a total catchment area of 51,000 sq. miles, excluding the delta catchment, only, 19,500 sq. miles lie in Madhya Pradesh. Before the Mahanadi enters the delta area, it flows mostly through steeply sloped upland. The land is studded with low hills some of which rise up to 5,000'. There are plateaus as high as 3,000'. The fall in the river bed from where it leaves Madhya Pradesh to Cuttack is nearly 580 feet. The major bed of the river varies in width from $\frac{1}{2}$ to $1\frac{1}{2}$ miles and is strewn throughout with rocks of various shapes. Between Chiplima and Dholpur, a distance of 87 miles, the slope of the river is 252' per mile and the river has more than 75 rapids. The rocky bed and large number of rapids present special problems for navigation on the upstream side above Dholpur.

The catchment area of the Mahanadi above Naraj is 51,000 sq. miles, as big as England and 10,000 sq. miles bigger than the catchment area of the Tennessee river. The average annual rainfall in the catchment area is 53.17". The mean annual runoff of the river at Naraj is 74 million acre ft. which is almost five times that of the river Colorado in the U.S.A. at the site of the Boulder Dam, the highest in the world. The mean annual run-off of the Indus at its debouch in the plains

at Kalabagh is 87 million acre ft., of the Columbia at the Grand Coulee Dam 80 million acre ft., and of the Nile at the Aswan Dam 66 million acre ft. This run-off of the Mahanadi at Naraj will fill the reservoir formed by the Mettur Dam in Madras more than 30 times. Run-off is the residual of rainfall after the deduction of losses by evaporation and transpiration.

The mean annual discharge of the Mahanadi is about 1 lakh cusecs which is nearly two-third of the total discharge of all the canals and irrigation wells in India which irrigate some 70 million acres of land each year. A small fraction of this enormous water wealth is at present being put to beneficial use for purposes of irrigation, the rest is running to waste causing untold damage and destruction through floods in its passage to the sea.

The discharge from the river sometimes attains a peak of 15 million cusecs. It, however, fluctuates widely between dry and wet weather, the minimum recorded in dry weather being only 200 cusecs, which a channel of 35' x 2½' can easily carry. In the dry season, it is generally between 2,500 and 1,500 cusecs. In some places, when the discharge falls to 1,000 cusecs, it becomes impossible to find a channel having, on all its points, a width more than 5'. Such a wide fluctuation in its discharges not only detracts from the usefulness of the river but also makes it positively destructive. During rains it swells and causes floods, while during dry seasons it shrinks and hardly serves any purpose.

For this vagrancy, rivers have been called by various names, e.g., 'River of Sorrow,' 'River of Destruction,' etc. But do they really deserve these names? The multi-purpose river valley projects have provided the right answer to this question. They have turned a hitherto natural calamity into a national resource. This holds good for the Mahanadi as well. The river, so far known for its devastation, will be revered

on the completion of the project, as the best friend of the millions of people living in its basin.

Like all other rivers of the peninsula, the Mahanadi has also reached the base level of erosion, resulting in a very shallow channel full of sand and silt, especially in its lower reaches. This channel is incapable of holding the huge volumes of water during the monsoon. If a circle of 25 miles radius be drawn with its centre at Naraj, the branches of the river crossing that circle are capable of discharging only half the volume of water which the Mahanadi is calculated to carry during peak flood. Thus floods in the Mahanadi have become a serious problem in the central delta.

The floods caused by the river merit serious attention for another reason. The Mahanadi delta extending over 2,300 sq. miles constitutes nearly 70% of the Central Delta, the most fertile and densely populated tract in Orissa. The Hirakud Dam Project should, therefore, prove a boon to Orissa, as it offers protection against flood to the major Delta area in the State, ensures the prosperity of its agriculture through an assured and stabilized water supply all the year round and provides energy for its industrial development.

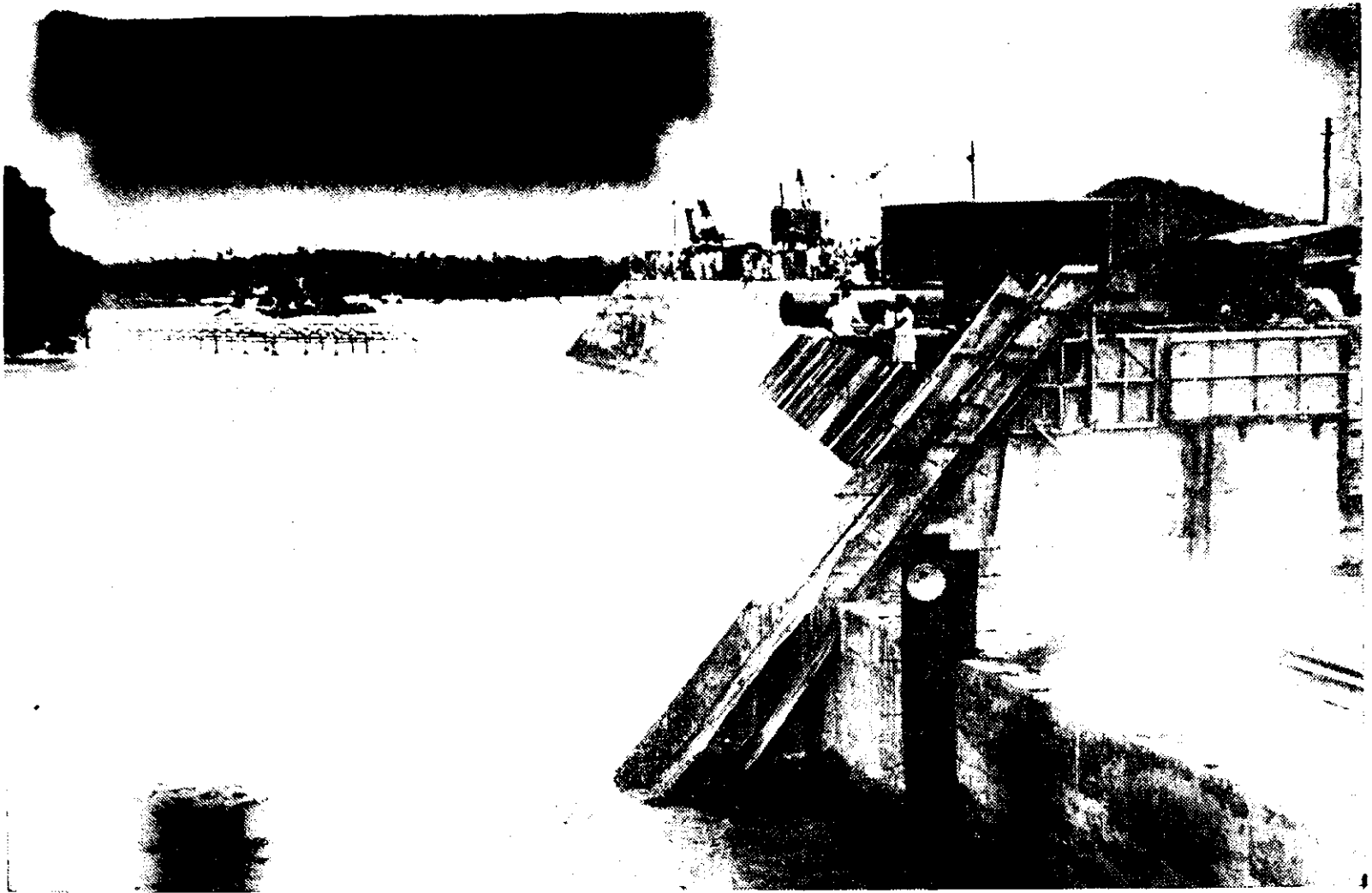
CHAPTER III
INVESTIGATIONS, PLANNING AND DESIGNS

The upper valley of Mahanadi was most unattractive and ravaged by intensive malaria

Orissa had no engineering college so that the available technical personnel were few. Even these were found in the relatively prosperous areas of Cuttack and could not be attracted to upland areas. The data to be collected were immense. Thus there was no single favourable factor conducive to speedy completion of the investigations. Nevertheless, the Central Water and Power Commission made a concentrated effort. In a period of less than 2 years, a large amount of data was collected. A preliminary project report was prepared and submitted to Government on the 12th June, 1947. The scheme suggested construction of three reservoirs ultimately and recommended Hirakud Dam Project to be taken up immediately as being the simplest in physical features, and construction requirements.

The Earlier Project Proposals

The suggested project comprised a dam across Mahanadi about nine miles upstream of the town of Sambalpur, gravity and lift inundation canals on either side and two hydro-electric installations. The dam as proposed was to be three miles in length across the main channel with 12 miles



Hirakud Spillway

length of low dykes on the two sides. The maximum height of the dam was to be 150 ft. and the storage capacity was fixed at 5.3 million acre ft. of which 1.2 million acre ft. was dead storage to serve as a silt reserve and provide minimum working head for generating power. The total area to be irrigated was nearly 11 lakhs of acres of which nearly half was to be irrigated by lift canal. The power was proposed to be generated in two parts. The station at the main dam was to utilise the head difference created by the construction of the dam. The second station was to utilise the rapid fall in the river itself by taking a power channel for a length of 17 miles with a more gentle slope than the river. The total installed capacity was to be 3,50,000 kW. Navigation locks were also to be provided in the dam so that at a future date, there could be uninterrupted navigation between the sea and the upper reaches of Mahanadi.

The scheme was considered by a Committee consisting of Dr. J. L. Savage (U.S.A.), Shri M. Narasimhaiya (Chief Engineer, Mysore) and Shri S. A. Gadhary (Chief Engineer, Punjab). The Committee generally approved of the project and suggested alterations in power output and storage level. The area to be irrigated by lift canal was also reduced to a third of the figure originally proposed.

Preparation of Designs

In earlier times, the construction of dams was spread over a large number of years so that design and construction could proceed simultaneously. Modern construction practice which lays emphasis on speedy execution does not conform to the old procedure. For this, it is of great importance that all the designs must be prepared with the utmost care before beginning the construction work. Various alternatives have to be studied and the cheapest has to be selected. Materials

of construction have to be carefully considered and selection has to be made to suit the conditions prevailing at site. Depending on the main material of construction, plant layout has to be drawn up and purchase specifications made available to the construction organization. Thus, in the modern technique construction, a preliminary stage has become necessary in which designs have to be carefully prepared. For this purpose, it is necessary to build up a special designs organisation. This necessity was realised early and a Central Designs Organisation was set up in the Central Water & Power Commission for preparation of designs for the major projects in the country. The building up of the organisation took some time. Meanwhile, as decided earlier, the International Engineering Company at Denver (Colorado) was entrusted with portions of the work. Some of the officers of the Central Water & Power Commission were also sent to Denver to receive training in designs. The International Engineering Company submitted the designs in December, 1949. A revision of the designs became necessary in the light of the additional data that were being collected. By the end of 1950, the Central Designs Office at Delhi was fairly well equipped to deal with all the designs of Hirakud Project. The new designs office was confronted with one of the major designing tasks of the country to be completed in the shortest time possible. By sustained work the final design and specifications were finalised by June, 1951. They were printed and made available to the construction staff by September, 1951. The structure, as built today, is practically as conceived by the designers in 1951.

It is, to be noted in this connection, that many intricate problems had to be tackled by the designers before final drawings were prepared. A few instances are given below to illustrate the difficulties met with and the methods adopted to overcome them.

(i) *Masonry Dam*

The cost of a project depends on the economic designs of its component parts. Of these, the spillway for letting out the flood waters is an important item. To calculate its proportion, we should know the maximum discharge of the river. The assumption of a low figure will endanger the structure; an extravagant figure will on the other hand, result in wasteful expenditure. Correct assessment is therefore necessary. But unfortunately there is no simple direct method to calculate the figure. Various methods have to be adopted and figures chosen with appropriate skill.

The International Engineering Company had used the data relating only to 6 rivers to obtain the peak flood by envelope curve. Envelope curves were redrawn on the basis of the observed data covering in all 75 rivers (2 in Newzealand, 23 in America, 5 in Australia, 42 in India, 2 in Europe and 1 in Africa). The peak flood at Hirakud from these envelope curves was estimated at 15 lakh cusecs. For obtaining the flood hydrograph and the volume of the design flood having a peak of 15 lakh cusecs, the principle of unit hydrograph was used. The severest flood on record at Sambalpur having maximum volume was magnified in the ratio of 15 lakh cusecs to the observed peak discharge. This is in line with the accepted principle of unit hydrograph. The design flood volume according to this method came to 11'6" on a 12 day basis compared to 16'9" as obtained earlier for the same time-base.

Frequency studies were also made for the precipitation as well as the peak discharge for the Mahanadi catchment at Hirakud. According to this study, the discharge for frequency of once in 500 years also came to 15 lakhs of cusecs, thus confirming the revised value obtained by envelope curves.

With this revised design hydrograph, the spillway was redesigned with respect to the following limiting conditions :

- (i) Safe discharge at dead storage level to be 6.5 lakh cusecs.
- (ii) Maximum reservoir level during peak flood not to exceed R. L. 630.

The single spillway as designed by the International Engineering Company gave a high intensity of flow on the left channel. Again, with the passing of the discharge into the left channel alone, as proposed by the International Engineering Company, the left colony could not be developed. It was, therefore, thought advisable to have two spillways; one in the left channel and the other in the right channel, the left channel carrying about 60% of the total discharge. With this modification, the deep channel portion was proposed to be blocked by an earthen dam thus effecting economy.

For the design of spillway, various combinations of crest gates, siphons, and deep-set sluices were considered and comparative costs worked out. The most economical and efficient arrangement for the spillway was thus evolved with 34 numbers of 51' × 20' crest gates and 64 numbers of 12' × 20'33' deep sluice gates.

One may wonder why so many sluices have been provided. Hirakud Dam is practically unique in this respect. Aswan Dam in Egypt also has 180 sluices; but these act under a head on only 22' to 45' and are of smaller size (40 of size 6.65 × 8.2 and 140 of size 6.56 × 23). At Aswan, due to the presence of sluices, the reservoir has not been silted up in spite of the 54 years of its existence. The object of the sluices in Hirakud is similar to the one at Aswan. By reducing the silt accumulation, it is intended to lengthen the life of the reservoir. It is true that in Aswan the ponding is not so great as at

Hirakud at the time the flood waters are let out. Nevertheless it is felt that similar effects as at Aswan will be attained at Hirakud specially due to density currents which can transport considerable sediment. The large number of sluices increased the number of intricate problems to be solved. Thus to operate the sluices, a gate gallery of 2,125 ft. had to be constructed inside the dam. This is the biggest spillway gallery that has ever been constructed in any dam in the world.

The masonry portion of the dam consists of three sections, each serving its own purpose. The spillway section is in two parts and totals 2,091 ft. and serves to discharge 5,25,000 cusecs on the crest and 8,18,000 cusecs through the sluices. The non-spillway section serves to give proper connections between spillway and earth dam. A portion serves also for the installation of penstocks for power generation. The total length of the masonry portion is 3,763 ft. and careful investigations had to be done to determine the character and suitability of the rock. Most of the dam is founded on substantial foundations which consisted of granites on the left section and portions of the right section. In the extreme right, soft rock was found. In the junction area, a zone 9 ft. long was crushed and sheared. The boreholes did indicate this but it was not thought that the damage to the rock would be extensive. Actual excavations revealed the necessity of extra precautions in this reach known as blocks 53 and 54. The design finally adopted consists of excavation to 21 ft. lower than in neighbouring blocks of shaft 15 ft. diameter at the front, excavation to 33 ft. of the sheared portion and backfilling with concrete and provision of a special gallery at a lower level to enable grouting at a latter date. The bearing capacity of the rock was also determined by field tests. The observations indicated that at the intensities of pressure expected on the completion of the dam, the rock would not settle in any noticeable manner,

(ii) Earth Dam

The Hirakud dam is conspicuous for another feature. It has the longest earth dam in the world. The flat topography of the country necessitated such large length of earth dam. In earlier times, the project would have been given up and valuable utilisation of Mahanadi waters lost. With the aid of modern technique of selection of materials, design and construction, there is no limitation imposed by conditions of stability either for the length or height of an earth dam. If a masonry dam were adopted as in earlier times, the cost would have been prohibitive. The earth dam became possible due to prior establishment of an up-to-date Field Laboratory and excellent survey of suitable soils. It may be rightly said that this Field Laboratory is one of the best soil laboratories in the country. The work handled by this laboratory has been explained in detail in a subsequent chapter.

The main earth dam as finally designed is in two parts. The left earth dam between the left abutment and the left channel concrete dam and the Hirakud Island Earth Dam between the left channel and right channel concrete dam. The left Earth Dam is about 4,400 ft. long and Hirakud Island Earth Dam is 7,648 ft. long and Earth dam is of zoned, rolled earth fill type. The maximum height for the major part of the dam is about 130 ft. and in the deep river channel it is about 195 ft. As of date, the Hirakud Main Earth Dam will be the highest earth dam in India.

The typical section for the earth dam as designed has a top width of 25 ft. The upstream slope is 3 to 1 with a 10 feet berm at elevation 580. The down stream slope is 2: 1 with 5 ft. berms at elevation 620, 590 and 10 feet berm at elevation 540. A road at elevation 557 on the down stream slope of the earth dam throughout the entire length serves as an access to the sluice gate galleries in the concrete dams. The crest is

25' wide and is topped with an all-weather metalled roadway continuous with the roads on the tops of the concrete dams. The crest elevation is 642 providing a free board of 12' against the maximum reservoir elevation of 630.

A heavy rock toe has been provided on the down stream side. This contributes to the stability of the dam by its weight, higher angle of internal friction and by providing drainage for the downstream part of the embankment. The height of the rock toe has generally been kept as one-fifth of the height of the dam. The top of the rock toe has been kept not lower than elevation 540 anywhere to take care of the maximum expected tail water on the downstream side. A cut-off trench has been provided at the upstream edge of the impervious zone with a base width equal to one-half of the height of the dam, subject to a maximum of 50 ft. (except in the deep channel where the width will be 100 ft.). The trench extends 2 ft. into compact bed-rock or other impervious stratum. A single line of grout holes, to extend 30 ft. deep and spaced 20 ft. apart, has been provided to cut-off any seepage through cracks and fissures in the rock. A three-layer filter blanket has been provided on the downstream side under the semi-impervious zone to safely lead out any seepage water, without any danger of fine particles of the embankment being carried off by it. The upstream slope is protected by hand-placed rip-rap, which will have a thickness of 4 ft. above elevation 580, that is in the range, subject to wave action. Below this, the thickness is 3 ft. The downstream slope is protected from the erosive action of wind and rain by turfing.

The design of the maximum section above elevation 510 is similar to the typical section discussed above. Below elevation 510, the rock toe with 20 ft. top width is added to the existing 3 to 1 earth slope making the outer slope 4 to 1. The impervious zone on the down stream side is given a re-

entrant slope of 1'35 to 1 thus maintaining a certain minimum thickness of semi-pervious material between the impervious zone and the rock fill. The downstream rock toe is proportionately more massive. The sections adopted were tested for stability and the computed factors of safety for the deep channel portion are for upstream slope 1'7 and downstream slope 1'4.

A contour road connects the top of the earth dam at the left abutment to the other features of the project.

The junction connecting the Hirakud Island Earth Dam with the left channel concrete dam and the right channel concrete dam is effected by lapping the earth dam around the end of the concrete dam in a circular arc to form a half cone. To reduce the length of the concrete dam required in the transition, a low retaining wall is put in to support the earth. On the downstream side, the retaining wall also serves as a training wall to protect the toe of the earth dam against the action of the spillway discharge. The junction between the left earth dam and the left channel concrete dam is effected by gravity type retaining wall.

The gravity retaining wall on the left side is probably one of the biggest structures of its type. The only parallel is the Fifteen Miles Falls Project in U.S.A., but this is across a narrow width of 900 ft. and is wedged in against high ground. Similar favourable factors are not present at Hirakud. The present design of a retaining wall to stem back the earth fill and provide a connecting link is a bold idea and has effected considerable economy.

(iii) Dykes

The main earth dam is flanked on either side by dykes. The right dyke is 7 miles long and is 30 ft. high on the average.

It is in a continuous stretch and presents a picturesque spectacle as it is viewed from the top of the right abutment hill. The left dyke, however, is different in pattern. It is five gaps of 1, 0·7, 2, 2·5, and 0·24 miles in length and of average heights of 43, 48, 15, 21 and 25 ft. respectively.

As the left dyke falls in the saddle from one hill to the other, it is hidden and not so imposing as the right dyke. The volume of earthwork that has gone into the main earth dams and dykes is by far the largest that has ever been done on a single dam in India. Even when compared with other earth dams of the world, it will rank among the first ten. The volume of earth put in the main dam is 16·5 million c. yds. and in the dykes 7·3 million c. yds. The magnitude of the work can be seen from the fact that it exceeds the total earthwork put in the four largest earth dams in India approved under the First Five Year Plan, namely Lower Bhawani (6 million c. yds.), Gangapur (5·48 m. c. yds.) Maithon (4·5 m. c. yds.) and Panchet (5·8 million c. yds.). Designing of such large earth dams involved tremendous work in selecting the proper type of soils, designing the sections and continually watching and controlling the construction procedures. The best materials of construction for earth dam were not available and use had to be made of the materials in the vicinity. Thus the difference in the average characteristics of impervious and semi-pervious materials was not all that could be desired. The clay content of the semi-pervious was 7% to 34% and is not distinctly different from the impervious. But by careful processing and day to day sorting, some distinction was sought to be secured. The soils, however, possessed good density, being 112 lbs. per c. ft. for impervious and 116 lbs. per c. ft. for semi-pervious. The plastic limit of the soils varied from 15% to 23% and was

considered good. Other characteristics of the soil are given below :—

	Impervious	Semi-pervious
Moist weight lbs. per c. ft.	130	134
Saturated weight	132	137.5
Submerged weight	69.5	75
Angle of int. friction	20°	31°
Tangent	0.364	0.6
Cohesion lbs. per sq. ft.	1000	700

Where the earth dam crosses the deep ravine in the bed of the river, greater care was bestowed on the design. The ravine itself presented exposed irregular blocks of stone and a number of precautions were taken.

In order to obtain scientific data and to serve as an indicator for the behaviour of earth dam, modern equipment for measurement of pore pressures inside the earth dam at different elevations and settlement apparatus which gives the settlement of each 5 ft. layers of earth dam were installed. This is the first time that such scientific installation was made in India and this was fully justified by the valuable data obtained subsequently.

The construction plant layout was also designed by the Central Designs Office at Delhi. The Technical Cooperation Administration of the United States rendered valuable aid in the procurement of some machinery

(iv) *Power House Designs*

Though Hirakud Dam was originally conceived as a flood protection measure, it was soon felt that power should be generated to the maximum extent. All the designs of the power system were accordingly undertaken and completed in the Central Water & Power Commission. This is the first system where the design of a complete power house for a large installed capacity was tackled in India.

For power generation, the power studies and reservoir operation studies with the latest inflow data and irrigation requirements were made afresh and total power potential of the project determined. The average head available at the main and the subsidiary power houses was calculated to be 87' and 75' respectively. With these studies it was found that 7 units of 37,500 kW at the main dam and 4 units of 24,000 kW at subsidiary dam would be the most suitable and economical arrangement.

While the construction was in progress, it was decided by the Government of India, that 'irrigation' should be given foremost consideration. Consequent on this decision, the work on the subsidiary dam and power station had to be deferred and the construction of the main dam proceeded with at a faster pace than originally scheduled. With the postponement of the construction of the subsidiary dam, it was felt that the generating units and the equipment ordered for the subsidiary power station could not be immediately used. Detailed studies were made as to how best these could be used in the main dam itself. Various alternative studies were made in consultation with the manufacturers of the equipment and the problem was successfully solved.

The equipment with suitable modifications was used in the power house at the main dam. The complicated hydraulic and structural design problems that arose were also adequately solved. As finally decided, the installation consists of 2,32,500 kW (including one spare unit at main dam and 72,000 kW in the subsidiary system).

The layout, general design and the detailed design of the power house was worked out entirely by Indian Engineers. The machine hall of the power house is 515' long and 70' wide. The generating units are spaced at distances varying from 63' to 104'-2". The spacing of 104'-2" became necessary

between units 2 and 3 since unit 2 (37.5 M.W.) and unit 3 (24 M. W.) unit have clockwise and anti-clockwise spiral casing. The power house is divided into individual unit blocks by construction joints. These joints extend from the foundation rock to the roof of the power house.

The control room, office space and other auxiliary rooms are conveniently located upstream from the units and over the toe of the intake blocks.

In addition to the above, specifications, schedule of materials for the two power stations for gates, turbines generators were prepared by the Commission to facilitate invitation of tenders. The detailed fabrication drawings for gates were also prepared so that it may be possible to manufacture these at the workshop located at site.

(v) *Gates and Other Features*

In any modern design of a dam structure gates form invariably a very important unit. In the case of Hirakud, gates have a larger importance due to the number and the large size of the gates. Complete designs for sluice gates, crest gates and other types were made in the Central Water & Power Commission together with specifications. Due to the thoroughness with which the designs were prepared the tender amounts for the gates were much lower than would have been otherwise.

Materials of Construction

As stated already, all types of construction materials of earth, masonry and concrete have gone into the making of the Hirakud Dam. This was necessary due to the nature of construction. Earth had to be employed to reduce the costs. Granite rubble stone-masonry was used in the power dam structure and the transition walls between the earth and concrete sections instead of the usual concrete, in cement

mortar. Very good granite stones were available within 7 miles of the dam site and were made full use of. This not only speeded up construction but also reduced the costs. Concrete could not be avoided as there were a large number of sluices and galleries in the structure and concrete was the best material to be moulded into different shapes. Materials were carefully selected after elaborate field and laboratory tests. Economy of cost was the aim at every stage. In order to improve the workability of cement, air entraining agents were employed. The Hirakud Research Station evolved an air entraining agent which proved as efficient as the imported ones.

Hydraulic Model Studies

Some features of the dam such as shape of overflow dam, shock absorption arrangements for the falling waters etc., are to be determined by hydraulic model tests. The designer indicates the probable dimension and shapes and models are constructed and tested under flowing water. Pressures and other data are measured and suitable alterations where indicated made in the original designs. Several hydraulic tests were conducted at Poona Research Station to fix the dimensions of the spillway training walls, effect of sluice openings etc.

Alterations During Construction

There were very few alterations in the masonry portion of the dam during construction.

There is a difference of 335'40 m. cft. in the storage capacity of the reservoir between elevation +625 and +630. The need for increasing the capacity of the reservoir was realised and advantage was taken of the difference between the FRL 625 and the maximum reservoir level of 630 by fitting in gates up to +630. Originally it was intended that the reservoir level was to be at +625 to be safe during floods. Now the

reservoir level has been increased to 630 by increasing the size of the gates. This change does affect the designs. But greater care will be exercised during the filling operations of the reservoir. The full reservoir level of 630 will not be kept till the peak flood of the season is over.

Unlike the concrete dams, earth dam designs are not deemed final till the actual construction is over. Continual changes are effected to suit the foundation conditions and available borrow materials. Even so, it should be stated that changes in earth dam portions at Hirakud are practically very few.

Canal Designs

The designs of canals taking off from the main dam could not be prepared to schedule as in the case of dam, as a large amount of field data had to be obtained. The main canals as well as 150 canal structures were designed in the Central Water & Power Commission. A branch office of the Central Designs Office was set up for a time at Burla (Hirakud Colony) to expedite the designs. Later on, to speed up the work, the design work was entrusted to the Chief Engineer at Hirakud.

The design of the canals and structures presented interesting problems. The water requirements of the crops had to be decided keeping in view the rainfall of the locality. The average annual rainfall is 55-60 inches and making allowance for this, the main canals and branches have been designed for a duty of 100 acres to the cusec. The right side canal was designed for 3.8 lakhs of acres. The canal can carry an additional 980 cusecs in the first 23 miles to facilitate at a future date supply of water to the lift canal to irrigate a lakh of acres.

As these canals run on contour for a major portion of their length, they have to cross many drainages in their alignment. For design of suitable cross drainage works, a proper assessment of the maximum flood discharge from the catchment area of these drainages was first arrived at. All the major aqueducts have been designed with 25' span. Well foundations have been adopted where sand is found to a considerable depth below the river bed. The design is similar to those adopted for the major aqueducts across the Krishna, the Godawari and the Hagari rivers.

Bridges have been provided at suitable intervals to provide access to the villages served by the canal. Where the crossings are in deep cutting arch bridges have been provided. At other places, R. C. bridges of T-beam or plain slab type have been provided. Highway crossing bridges have 22' roadway, while for district and village roads, a roadway of 12' width has been allowed. R. C. Standard loading of the 'A' class or 'B' class as required by the specifications, were adopted in the design of these bridges.

There are no major falls on the main canals but on branches, distributaries and minors, drops have been provided wherever necessary. For small falls involving larger discharges, vertical drops with the water cushions have been adopted. For other unflumed glacis type falls with hydraulic jump cistern and baffle wall have been adopted. For relatively smaller discharge, well type drops have been allowed.

CHAPTER IV

HIRAKUD DAM PROJECT

The Project derives its name from the island of Hirakud. The river at the site of the dam runs into 3 channels, forming two islands named Hirakud and Koilarkud. Hirakud is nearly 8 miles long, its maximum width being about three quarters of a mile. *Kud* in Oriya means an island; Hirakud, therefore, literally means 'Island of Diamonds'. It is so named because of its past association with diamond washing. Earlier records contain accounts of diamond washing at Hirakud from the gravel accumulation in the northern channel of the river, but the mineral survey of the area conducted in 1947 did not reveal the presence of diamonds there. The conclusion was that the diamonds reported in the previous centuries were washed down from other areas and deposited along with the gravel.

It will be interesting to note in this connection that there was a certain amount of local opposition to the Project in the beginning. It is a general feature all over the world and perhaps to a greater extent in India that opposition starts as soon as any big project is started. The magnificent attempts of Sir Arthur Cotton in harnessing the Godavari and the Krishna in the south and of Sir John Cautley in harnessing the Ganga in the north evoked great opposition. Similar opposition was offered to the construction of the Krishnaraja Dam and the Bhadravati Iron Works. Hirakud was no exception. There was a large measure of opposition from the



Left Spillway of the Hirakud Dam

local population as soon as it was decided to proceed with the project. "Anti-Hirakud" campaign was reinforced by the fact that a large population was to be displaced from the reservoir area. The opposition gathered even technical help and asserted that due to the large amount of silt in the river, the life of the reservoir would be limited. Some critics put it as low as 12 years. The extreme unreasonableness of some aspects of the opposition served only to speed up the measures towards the implementation of the project.

The three main objectives of this Rs. 100 crore multi-purpose river valley project are irrigation, power generation and flood control. The project is to be completed in two stages. Stage I comprises the construction of the main dam and appurtenant works, canal system in the Sambalpur and Bolangir-Patna districts, and power generation at the main dam. The programme of power generation consists of a power house for four generating units, 9 sub-stations and over 500 miles of transmission lines. The work on Stage I started in April, 1948, and is almost complete. Water for irrigation has been made available from 7th September, 1956. Power will be generated from ~~September~~ ^{January} 1957. The total cost on Stage I is Rs 70.78 crores distributed over various items as given below :—

Unit 1—The Main Dam and appurtenants works	Rs. 45.50 crores
Unit 2—Main Canal, branches and distributaries	Rs. 8.12 crores
Unit 3—Power generation	Rs. 16.27 crores
Unit 4 and miscellaneous, including delta investigation, sales tax, etc.	Rs. 0.89 crores

The Delta Irrigation Scheme which was subsequently sanctioned at an estimated cost of Rs. 14.92 crores and which

is being executed by the State Government is part of Stage I of the Project. The second Stage provides for subsidiary power development at Chiplima, 17 miles below the dam, at an estimated cost of Rs. 14.32 crores.

The salient features of the whole project are given below;—

Full Reservoir Level	R.L. 630'00
Maximum Water Level	R.L. 630'00
Gross Storage Capacity	6'60 million acre feet
Dead Storage Capacity	1'88 million acre feet at 590'00
Live Storage	4.72 million acre feet

Main Dam

Total length	15,748 ft.
Length of Concrete and Masonry Dam	3,768 ft.
On left side	1,640
On right side	<u>2,128</u>
	3,768 ft.
Quantity of Concrete and masonry	1.4 million cubic yards
Length of Earth Dam	11,980 ft.
Length of Dyke	
Right Dyke	35,500 ft. in one stretch
Left Dyke	32,275 ft. in 5 gaps Spanning Hillocks
Total quantity of Earthwork in Dam	237 million cubic yards
Maximum height of Masonry Dam above foundation	200 ft. (Power Section)
Maximum height of Earth Dam	195 ft. (at the deep Channel Bed)
No. of Under sluices	64 (40 on the left and 24 on the right)
Size of Under sluices	12'-0" x 20'-4" each
Sill Level of Under sluices	+ 10.00 R.L.

Crest Level of Spillway	+ 610.00 R.L.
No. of Crest Bays	34 (21 on left and 13 on right)
Size of Crest Spillway Gate	51'-0" x 20'-0"
Designed Maximum Flood Discharge	1,500,000 cusecs

Canal System

Culturable Area	15,31,000 acres
Annual Irrigated area	25,39,094 acres

Power

Main Power House

Average Head	87 ft.
No. of Generating Units	2-37'500 kW each } 2-24'000 kW each } (I Stage)
	1-37'500 kW (II Stage)

Subsidiary Power House

Average Head	78 ft.
No. of Generating Units	3-24'000 kW each (II Stage)

Transmission and Sub-stations

Total Length of Transmission Lines	
132 kV	418 route miles
66 kV	90 route miles
Nos. of Grid Sub-stations	9

The project will utilize only one-seventh of the Mahanadi waters.

Main Dam

It is located across the Mahanadi below the confluence of the 'Ib' river and about 9 miles upstream of the town of Sambalpur. Here the Mahanadi river is a little over two miles wide and is flanked by two hills. One arm of the dam joins the

hill named Chandli Dongri which rises steeply from the river bed on the right side. The left arm of the dam abuts on the hill—Lam Dungri which is situated at a small distance from the river bed.

The Hirakud Dam comprises a masonry power dam, right and left concrete spillways with a total length of 3,188 ft. and earth section 11,980 ft. long. The concrete sections of the dam have been built on the right channel and on the rocky portions of the river bed close to the left bank. One of the earthen sections spans the Hirakud and Koilarkud islands between the two spillways and another connects the left concrete dam with the left abutment hill. The Power Dam is on the right flank of the Right spillway.

The Main Dam is about 3 miles long flanked by 13 miles of dykes on the right and left sides. The main dam together with the dykes, with hillocks in between forms a 22 mile bund across the Mahanadi draining at the site 32,200 sq. miles of the country-side with the maximum flood discharge exceeding a million cusecs. It is mainly an earthen dam. The total length of the earth portion of the main dam is nearly three times that of the concrete and masonry sections. In addition, the thirteen miles of dykes also consist of earthen embankments except the 800 ft. long gap No. 2 in the left dyke which is a masonry structure. There is a motorable road on the top of the main dam and dykes which provides a long, continuous and pleasant drive of 22 miles round the reservoir.

A considerable part of the foundation of the dam rests on sedimentary rocks which at many places weak in structure and needed special treatment. At places excavation was done as deep as 60' below ground level in some blocks to reach sound rocks of proper foundation grade. The power house foundation had to be taken down to 71 ft. below the river bed

to get passable foundation. The average depth of excavation in the right concrete section of the dam ranged between 25' and 50' from the original ground level. The total quantity of excavation for foundation done for the concrete and masonry sections was 226.68 lakh cft. of which 162.49 lakh cft. was excavation in rock. The faults and sheared and crushed zones in the foundation rocks were extensively grouted, *i.e.*, reinforced with cement. The total footage drilled and grouted in the foundation of the main dam was 97,741 including low and high pressure holes.

Dykes

The alignment of dykes is so fixed that they run on ridges. This has assured maximum storage with the least amount of construction work and considerable economy in cost. The right dyke is in one stretch a little less than 7 miles long. It has an average height of 29.8', the maximum being 43'. It starts at a distance of about 3½ miles from the right abutment of the dam and connects the hill on the right of the dam with the Barapahar hills at its other end. The Baragarh canal with a discharge of 4,800 cusecs, the biggest in the Hirakud Canal system takes off from this dyke. On the left side there are hillocks on the alignment line, the gaps in them have been closed with dykes. There the left dyke consists of 5 gaps. Except gap 2 which is filled with a masonry structure the rest are earthen embankments.

An irrigation sluice has been provided in the left dyke gap 2 to feed the Sambalpur and Hirakud distributaries. The former is designed for a flow of 120 cusecs and the latter for 8 cusecs. The main canal of the left bank called the Sason canal takes off from gap 4 and is designed for a discharge of 630 cusecs.

The construction of earthen embankments for the purpose of dam and dyke is not just a mechanical piling up of earth;

on the contrary, it needs high technical skill. The soil to be used must be suitable and should contain the right proportion of clay. Impervious soil is used generally to form the central core and the semi-pervious soil is used on the up and down stream sides of the dam. The earth is laid in layers not exceeding 9" in thickness. An optimum moisture content has to be maintained during compaction by spraying water over the earth in order to have the compaction to the required density. The construction of earthen dams is a combined field and laboratory task, requiring technical skill of both engineers and soil scientists. The construction of a 16 mile long earth bund also involved highly mechanised operation of digging and transporting the particular kind of earth needed and its compaction to the required degree. The magnitude of the constructional work in building up the masonry, concrete and earth sections of the dam and dykes can well be realised by the quantities of materials consumed, i.e., 23 million cft. of concrete in cement, 15.2 million cft. of hand-placed granite and masonry in cement, 442 million cft. of rolled earth fill in the Main Dam and 198 million cft. in the dykes. The rip-rap and rock fill laid on slopes and toe of the main earth dam over graded filter amounts to 33 million cft. About four lakh tons of cement and 45,000 tons of steel have been used.

Power Plant

The power dam has seven penstocks which are the largest so far installed in the country. Only four generating units, two of 37,500 kW each and two of 24,000 kW are being installed in the first instance. The total installed capacity at this stage will, therefore, be 1,23,000 kW. Two more of 37,500 kW each are to be installed later. A penstock opening has been provided for the seventh unit if required at any time to develop secondary power. The entire power plant is located at the right end of the dam. The dimensions of the power house are 618' × 132'. It is estimated that with the four

units installed now it will supply 73,000 kW of continuous power. At 60% load factor, the firm power potential is 1,20,000 kW. The head will vary from a maximum of 115' (R.L. 630 to R.L. 515) to a minimum of (590—515)—75 ft. During the monsoon, the operating head will vary between 70' and 55'. The power potential is much higher than 73,000 kW as the normal discharge of the river during this time is enormous.

At the lower power house at Chiplima, a head of about 78' is rendered possible by the natural fall in the bed of the river there. The firm power potential there is 54,000 kW continuous with three generating units of installed capacity 24,000 kW each.

Reservoir

The reservoir formed by the Hirakud Dam extends from the dam site 50 river miles upstream and covers an area of 283 sq. miles, *i.e.*, 1,84,598 acres in the two States of Orissa and Madhya Pradesh. The major portion of the area to be submerged lies in Orissa, only some small strips of areas affecting 34 villages partially along the river Mahanadi and its tributaries will be submerged in Madhya Pradesh. In the Sambalpur district, 249 villages have been submerged, 113 fully and the rest partly. Only 43 of the villages submerged were situated on the right side of the river as almost all the area on this side is hilly and covered with reserve forests. The remaining villages were on the left side where the country is comparatively flatter and contains long stretches of cultivated fields.

The area submerged on the left side of the river was very poorly developed. Except a few fair-weather roads, there were no railway lines, no bridges nor any major structure; so the losses resulting from submergence are quite low as compared to other big projects. There has been no loss of mineral wealth to the State. The geological survey did not reveal any mineral deposits in the area submerged.

The gross storage capacity of the reservoir is 6'60 million acre ft. of which 1.88 million acre ft. at R.L. 590 represents the dead storage capacity. The live storage of the reservoir will be 4.72 million acre ft. The reservoir level during the monsoon period will be kept at R.L. 590 so that heavy floods can be absorbed. The reservoir will be filled up to R.L. 630 by 1st October every year and the discharges of the downstream side will be made only through the power units from this date. The water in the reservoir not only enables generation of 73,000 kW of continuous power but also assures a continuous discharge of 9,000 cusecs to 13,000 cusecs in the river between October and June as against only 1,000 to 1,500 cusecs prior to the completion of the Project. This supply of water will be used for extending irrigation in the Delta area and also for the development of navigation facilities at some future date.

On the basis of figure of silt load in the Mahanadi, systematically estimated since the beginning of 1947, it has been calculated that it will take more than one hundred years for the reservoir to silt up to R.L. 590. Even after this period, the effective capacity of the reservoir will be such as to meet fully the irrigation requirements. Only the power production would be reduced slightly. With the implementation of the soil conservation programme in the upper basin, the silt load of the river will decrease considerably. Further, the general experience on the other reservoirs which have been in existence for over 25 years shows that the actual rate of silting is much slower than is anticipated. Therefore, the actual life of the Hirakud reservoir may turn out to be many years more than what the calculations based on the present silt load show. However, to be on the safe side, in the project proposals, the life of the reservoir has been assumed to be 100 years.

64 large river bed sluices provided in the spillways, further ensure passing down of the heavy silt-laden flows of the

river in the early part of the monsoon. As pointed out earlier, such an arrangement increases the life of the reservoir by reducing the silt accumulation in it to a minimum. Further, it allows the silt to continue to be deposited on the cultivated fields along with the canal water or when there is a light spreading of the river water over the fields during heavy rains. So the rich fertilizing value of the silt will not be completely lost to the farmers, particularly in the Delta area.

The mean annual discharge of the river at Hirakud is 50'0 million acre ft. most of it occurring during July—September. Therefore, there is no apprehension of the reservoir not being filled up in any year.

General Remarks

The entire project has been built by Indian engineers who have successfully solved the various problems that confronted them during the course of execution e.g., treatment of foundation rocks, batching and transport of concrete, use of heavy earth-moving machinery with maximum efficiency, selection of suitable soil, its proper placing and compaction in a 16 mile long bund with constant testing both at the field and in the laboratory, construction of large size river bed sluices and fabrication of transmission towers. The dam is not only a living testimony to the skill of our engineers but has also provided them with a rare opportunity of training and experience in the construction of large dams. Further, the project has made available a mass of valuable data for future use in dam building.

Before attempting a description of the role of the project in re-building Orissa and re-vitalising its economic life a picture of her existing state of economy is presented in the next chapter.

ORISSA—Its Land and Undeveloped Resources

Orissa provides the example of a State suffering from poverty amidst plenty. Nature has been bountiful to her. There are extensive forest reserves and rich mineral deposits in the State. The large volume of water carried by its river system is a potential source of wealth. Geographically, Orissa links up the North and the South and the East and the West of India. Its climate comprising a hot summer and a mild winter permits growing of a large number of crops. Many of the rainy season crops can also be grown during winter. Few states can excel her in the variety of tribal races. From time to time there have been waves of migration to Orissa. The population of Orissa is, therefore, composed of people from various parts of the country. But the people are poor. The rich resources of the State await mobilisation in their service.

Orissa has a rich heritage. It formed part of the ancient Kalinga empire, which at one time extended from the Ganga in the north to Cape Commorin in the south and was the scene of the great Kalinga War fought by Asoka. The art of Asoka was influenced by the brave sacrifice of the people. The people were adventurous and carried their flags as far as Java and Sumatra in South East Asia. The State once enjoyed an era of peace and prosperity to which its great temples with their exquisite stone carving and the existence

of well knit village communities still bear silent testimony. About the Sun Temple of Konarak Percy Broan says :—

“Few buildings can boast of such an unrestrained abundance of plastic decoration as this vast structure, every portion of the exterior being moulded and chiselled either in the form of abstract geometrical ornaments, conventional foliage, mythical animals fabulous beings, half-human half-serpent coils, figures satanic and figures divine of every conceivable motive and subject known to the Indian mind and in a technique which ranges from patterns cut with minute precision of a cameo to powerfully modelled groups of colossal size.”

Under the British rule, Orissa was originally attached to Bengal. In 1912, it became part of Bihar and Orissa. In 1936, it became a separate province with six districts and a budget of barely Rs. 17 crores, too inadequate to maintain even the minimum administrative set-up. With the merging of 24 feudatory States in it, in 1948, after independence, Orissa has now an area of 59,000 sq. miles, as big as that of England, and a population of 14 million according to the Census of 1951. Almost two-thirds of its population belong to backward classes. The State is particularly rural in character. It has only one city and 38 towns. The number of villages is 50,984. It is also predominantly agricultural, the percentage of agricultural population being as high as 79.29. The percentage of urban population is 4.06 against 95.94 per cent of the rural population. The percentage of literacy is 15.80. The density of population per square mile is 244 against the average of 312 for India.

The State is divided into 13 districts of which 6 are coastal and 7 situated in the hilly hinterlands on the west.

According to topographic features, the State is divisible into four parts. In the north is the plateau covering an area of about 15,000 sq. miles. The hill ranges run from north to south and rise to 2500 to 3500 ft. above sea level. They are interspersed with fertile valleys. In the middle or heart of the State is the central table-land about 14,000 sq. miles consisting of watersheds of the three principal rivers, the Mahanadi, the Brahmani and the Baitarani. The region is an undulating plain with isolated hills and fertile valleys. The slope of the land and soil characteristics make it a well-drained area. Water flows rapidly into the hilly streams and the region often suffers from drought. The soil in this region according to its location, which also determines its fertility, is classified into 'At' or high land, 'Mal' or medium land, 'Berna' or lowland and 'Bahal' or bottom of the valley. The last is the most fertile and grows good crops of paddy. The farmers of the region are skilled agriculturists.

To the east and south-west of this table-land lies the Eastern Ghats with its thick forests and rice cultivation in the lower levels. The fourth part is the coastal tract or the delta area. It consists of plain land with productive soil. Floods are of common occurrence in this region.

The Hirakud Dam Project mainly concerns the central table-land and the delta region. Apart from the benefits of irrigation which both the regions will enjoy, the former will have great industrial development as a result of cheap power supply and the latter will be protected against floods.

Forests

Complete statistics of the forest area in the State are not available but roughly about one third of its total surface is covered with forests. The total area of forests under the management of the State Forest Department is about

17,000 sq. miles. These forests supply valuable timber, bamboo, grass and many other products. They are rich in medicinal plants and wild life. They yield revenue of about a crore of rupees annually but the income from them can increase considerably if they are well developed. Their full exploitation has been held up so far for lack of power and good roads. The Angul forests produce nearly 25,000 tons of bamboo per year but there is only one paper mill at ~~Cuttack~~ and the rest of the production is sent outside the State. The Central table-land including the major part of the Mahanadi basin has about 30% of its area under forests but, due to inadequate attention to its proper maintenance and uncontrolled grazing, the tract is subject to intense erosion during monsoons.

Mineral Wealth

The State is rich in mineral deposits. The north and north-west areas are among the richest sources of minerals in India. Among the important minerals found in the State are iron, manganese, dolomite, bauxite, limestone, chromite, coal and graphite. There are deposits of fire-clay refractories, china clay and ochre also. All its mineral wealth has not yet been surveyed. According to the estimates of the Geological Survey of India, the total reserves of iron ore are not less than 2,000 million tons. At present, Orissa supplies 60% of the iron ore consumed in India. The deposits of manganese and lime stone are estimated at 1,000 and 750 million tons, respectively. Within a short distance around Sambalpur there lies a good part of the mineral wealth of Orissa. Lack of power has been the most important limiting factor in its full exploitation.

Agriculture

The total cultivated area in the State is 12.5 million acres. Rice is the major crop occupying 9.2 million acres,

i. e., 73.6% of the total cultivated area. Its average yield is the lowest in India, being only 720 lbs. per acre as against 988 lbs. for the whole country and 1,010 lbs. and 890 lbs. per acre in the adjacent States. Autumn or *beali* and winter or *sarad* paddy which are sown in May-June and June-July and harvested in August-September and November-January respectively account for 99.2% of the total area under rice. About 11% is under autumn paddy. The area under summer rice, *i. e.*, second crop of rice, sown in December-January and harvested in March-April, is limited to 0.8% only. Pulses which are mainly grown during winter, occupy 1.3 million acres. Of the total cultivated land, 91.7% is under food crops and only 5.6% under cash crops, namely, jute, cotton, sugarcane, tobacco and groundnut. The area under sugarcane is 62,143 acres and that under potato 17,000 acres. Oilseeds occupy about 6 lac acres. Among oilseeds, *til* is the principal crop. Millets and gram account for 3.3 lac acres and 1.8 lac acres respectively.

Area cropped more than once a year forms about 16 per cent of the total cultivated area. It is only about 4% in the inland region and about 26% in the coastal region. It varies from about 5% in Sambalpur to 31.3% in Cuttack. The higher percentage in the coastal region is mainly due to irrigation facilities there.

About 20% of the cultivated area is irrigated but the major part of this irrigation is confined to *Kharif* crops only. Irrigation is most widely adopted in the coastal tract and Eastern Ghat region and is the least popular in the Northern Plateau and the Central table-land. In Cuttack the area under irrigation is about 60% as against 3.79% only in Sambalpur.

The average annual rainfall is 54" which is quite high, but as it is concentrated during the four rainy months, a *rabi* crop is difficult to grow without irrigation. The upland soils of Inland Orissa constituting about 55% of the total

cultivated area are not retentive of moisture for sowing a second crop in *rabi*. In the absence of irrigation facilities the *rabi* crops do not get sufficient moisture to thrive.

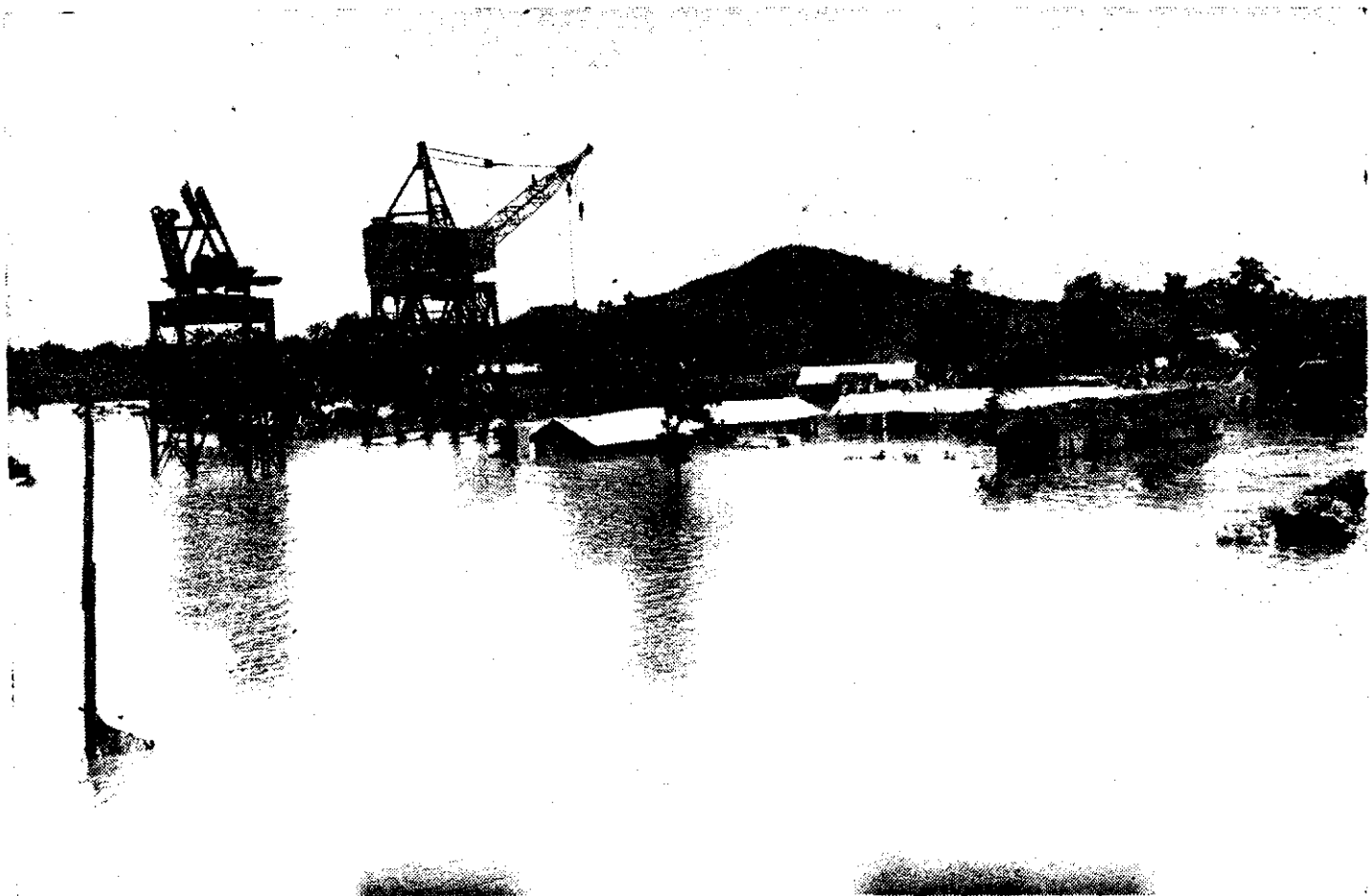
Thus in spite of the tremendous wealth in her manpower, water resources and mineral deposits, Orissa continues to be a backward State suffering from chronic poverty and haunted by the twin spectres of flood and famine. The reason is not far to seek. Her manpower is not properly employed. Her water resources are wasted without being utilised. Her mineral deposits await exploitation which cannot be achieved without cheap power. Thus the solution to the problem of Orissa, and her consequent prosperity, depends on the efficient use of her water resources for purposes of irrigation and power generation. The Project performs this task admirably and opens up a new vista of development in Orissa.

CHAPTER VI

FLOOD CONTROL

Floods have caused extensive damage to crops in the Delta, the most fertile and thickly populated region of Orissa. Floods have occurred in the area as many as 39 times since 1868. Between 1911 and 1937, floods occurred in nine years causing loss varying from Rs. 20 lakhs to Rs. 66 lakhs on each occasion. Besides loss to crops and property, floods cause untold human misery which is beyond measure in terms of money. The sense of insecurity concerning life and property has a very demoralising effect on the inhabitants in the flooded area. It paralyses their enthusiasm to live a better life or to improve their land, home and villages.

The question of control of floods has received serious attention since the middle of the 19th century. The most common method followed has been the construction of embankments to stop the rivers from overflowing. But these embankments have not proved particularly successful in checking the menace of floods and the people have continued to suffer from their ravages. So much so, a belief had grown that floods in the Delta were inevitable and that no effort could succeed in controlling them. The causes of floods have been the huge volume of water poured down in the delta area by the rivers, the flat nature of the delta and the shallow depth of the river channels in it. The carrying capacity of these channels is so low that during heavy rain-storms the waters overflow the banks flooding the area all round.



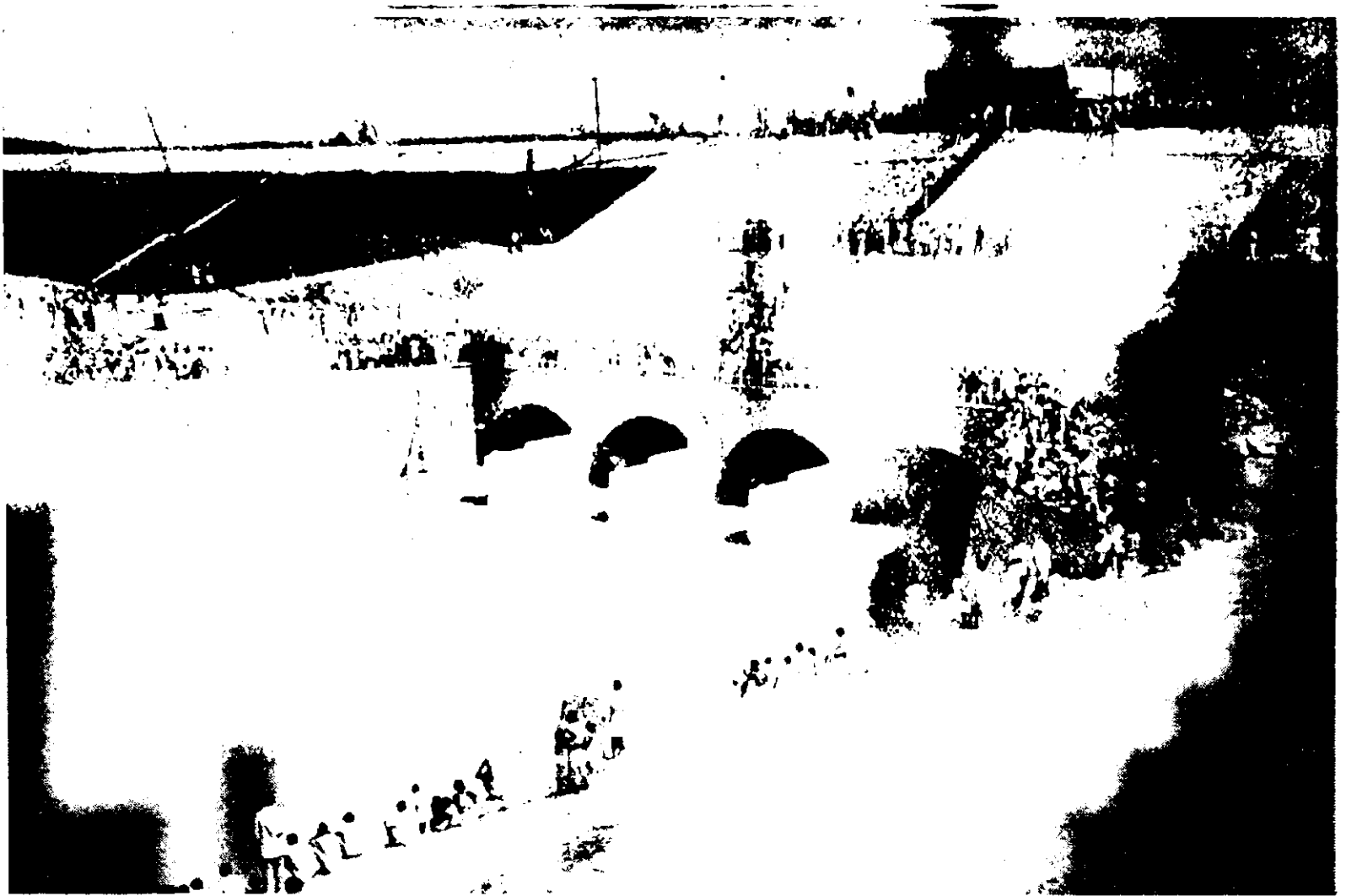
Flood at the Hirakud Dam site

The Mahanadi Delta accounts for about 70% of the Central Delta and the Hirakud Dam is so situated that it controls the flood waters of 67% of the drainage area responsible for causing floods in the Mahanadi delta. By simply retarding the flood peak from the upper catchment for a period sufficient to let the peak from the lower catchment area pass through the delta, the concentration of flood waters would be avoided and there can be no serious flood damage in the delta. The Mahanadi delta is only 50 miles wide and it takes about one day for the flood waters to pass ; therefore, the holding up of the flood water from the catchment area above the dam site only for a few days will allow the peak flood in the lower catchment area to pass without acquiring such a magnitude and concentration as to cause serious damage. The Hirakud Dam reservoir extending over an area of 288 sq. miles with a flood reserve of 472 million acre ft. will successfully hold the flood water until the flood peak in the lower catchment is drained off to the sea. The Project, for the first time, offers an effective solution to the problem of floods in the delta. In fact, the reservoir has already stood the test well. Even before completion, it successfully helped in minimising the intensity of the unprecedented floods of 1955 by lowering the discharge of flood waters in the delta by about 1/3rd. The floods of 1955 caused extensive damage. It is not difficult to imagine their devastating effect with this large volume of water further added to its intensity.

The records of 39 damaging floods have been examined and the effect of the Hirakud reservoir on controlling these floods studied. Assuming the safe gauge at Naraj to be 89.00 ft., it has been found that all the floods will be completely controlled without the reservoir being filled beyond an elevation of 620, while the maximum elevation is 630 ft. To control the serious flood that occurred in 1872, a maximum flood reserve capacity of 3'0 million acre feet was needed and

thus the reservoir can provide without going beyond the elevation level of 620 ft.

In years of exceptionally heavy rain-storms, the margin of 10 ft. in the elevation, which means an additional capacity for holding 1.72 million acre ft. over 3.0 million acre feet can be utilised to reduce the intensity of floods in the Delta. There is also a free board of 12 feet above R.L. 630. The reservoir level will be kept up to R.L. 590 during the monsoon period and there is provision for the discharge of rain water up to 7 lakh cusecs during this period through the large number of deep set sluices which are a special feature of the dam. Therefore, throughout the main rainy months, the reservoir will always have the maximum flood storage reserve of 4.72 million acre ft. It is thus obvious that it can help reduce the peak flood concentration in the delta area to the extent of the said quantity of water which roughly amounts to reducing the intensity of flood to about one half to two-thirds. It is a matter of common knowledge that floods are most devastating only if they rise beyond a certain maximum level; otherwise, they can even pass unnoticed. Except in abnormal circumstances, with unusually heavy rainfall in the lower catchment area and the reservoir full in September, the project guarantees full protection to the Delta which is 200 miles away from the Hirakud Dam.



Bargarb Canal-Water entering the canal at the head regulator site 7-9-1956

CHAPTER VII

IRRIGATION BRINGS NEW LIFE TO LAND

Agriculture in Orissa, by and large, means growing of one crop in a year although the climate is suitable for growing a rich variety of crops and the soil is fertile. Through centuries, not only has the welfare of the farming community but also the prosperity of the entire State depended on the success or failure of paddy which is the principal crop of the State. Orissa has a fairly high annual rainfall but it does not ensure a successful harvest of paddy. The crop has failed on an average once in three or four years. For want of rains during the remaining eight months of the year, *Rabi* cultivation is not possible without irrigation. Thus the rich land and climate have remained unutilised and with that the people's energy too. Water has been the chief limiting factor. The Project through its perennial canal system brings water in the first instance to about 6·72 lakh acres of thirsty land and promises a new life to the land and people of Orissa.

Government have also approved, as part of the first stage of the project, the Mahanadi Delta Irrigation Scheme. The scheme contemplates re-modelling of the existing canals and new weir across the Mahanadi at an estimated cost of Rs. 14·92 crores. On completion, it will provide irrigation to the existing canal area of 5·41 lakh acres as well as 5·36 lakh acres of new area. Taking into consideration the two crop pattern, the total area irrigated annually in the Delta will be 18·7 lakh acres.

Due to the undulating nature of the land through which the canals run, they have been aligned as contour canals. The canals cut through a number of drainages, but by providing adequate cross drainages, the natural drainage system has been disturbed the least. The canals will supply water throughout the year. A brief description of the canal system in the Sambalpur and Delta zones is given below :—

Sambalpur Zone

The Canal system in this area consists of :

1. Baragarh canal (Right Side Flow Canal)
2. Sason Canal (Left Side Flow Canal)
3. Sambalpur Canal.

1. *Baragarh Canal*.—It takes off from the Right Dyke. It is 55 miles long and is the main canal of this zone. It has a full supply capacity of 3,822 cusecs and a commanded area of 3,80,000 acres. It is designed to carry an additional 980 cusecs in the first 23 miles to facilitate supply of water to the left canal when constructed. The canal has two branches which take off at mile 6.5 and at mile 42.5 and have a discharge capacity of 900 cusecs and 540 cusecs respectively. The total length of the branch canals and the distributaries is 333 miles. There is also a considerable mileage of main and branch water courses with flow of one to three cusecs.

A cusec means the flow of one cubic foot of water per second. Duty of water is expressed in terms of area that can be irrigated with one cusec. It varies with the nature of crop and rainfall. If a crop needs more water the duty of one cusec will be less, i.e., it will irrigate a smaller area. The duty is high when the rainfall is high. The duty is high during rainy season and low during summer. It has been estimated that the duty of one cusec in the Sambalpur

canals is about 100 acres of paddy during *Kharif* and 50 acres in *Rabi*.

2. *Sason Canal*.—It takes off from gap IV of the Left Dyke and is 14 miles in length. It has a full supply capacity of 630 cusecs and commands a culturable area of 62,177 acres.

3. *Sambalpur Canal*.—It takes off from gap II of the Left Dyke. It has a discharge capacity of 120 cusecs and a commanded area of 11,802 acres.

Delta Zone

Proposals for improving and increasing irrigation in the Delta area have since been sanctioned. The scheme is expected to be completed by 1960 at a cost of Rs. 14.92 crores distributed as follows:—

(i) Remodelling the existing canal system	...	3.60 crores
(ii) New canals in Puri district coupled with flood control with the offtake of the new canal above the new weir upstream of Naraj	...	11.32 crores

The existing Delta canals have a designed capacity of 41,00 cusecs and they command a culturable area of 4.06 lakh acres. For lack of water courses to carry water to the cultivator's fields and due to the defective system of water distribution followed at present in which water passes through one field onwards to another, there is heavy wastage and water cannot often reach the distant fields. Numerous cuts have been made in the distributaries to take water to the fields. Due to this practice the distributaries are in a deplorable condition. The irrigation development has, therefore, not

been satisfactory and on an average, less than one half of this area is being irrigated.

It is proposed to remodel the existing canals to improve their capacity, to construct a new weir across the Mahanadi a few miles above Naraj and new canals in the three doabs, viz., Kathjori-Kushabhadra, Kushabhadra-Bharagabi and Bharagabi-Daya in the south-eastern portions of Cuttack and Puri districts. An additional culturable area of 1.35 lakh acres will be, thereby, brought under the command of the existing canal system and a further culturable area of 5.36 lakh acres under the new canal system.

The net result of the new Scheme will be that in the existing canal area 4,06,000 acres will be converted to perennial zone from its present non-perennial character and an additional area of 6,12,000 acres including lift perennial will receive perennial flow irrigation in both Cuttack and Puri districts. 59,000 acres will be newly brought under a non-perennial system in the narrow strip near the coast.

The Project provides a perennial system of irrigation to the land of Orissa for the first time in the history of its agriculture. For a proper appreciation of its full benefits, it is desirable to first describe briefly the agricultural features of the commanded area in the Sambalpur and Delta zones.

Characteristic Agricultural Features of Sambalpur Zone

As stated earlier, this area had four classes of agricultural land. 'At' accounts for a little more than one-third of the total commanded area by the new canal system in the Sambalpur zone, 'Mal' for a little less than two-third of the total commanded area. The specially good drainage of these lands makes cultivation on these lands a problem in the absence of irrigation. The rain water runs-off quickly and these soils do not retain moisture for long. Very little paddy

is, therefore, grown on 'At' lands. The yield of paddy on 'Mal' is poor and uncertain. Generally, the farmers do not pay much attention to the proper cultivation of these lands. The 'Berna' and 'Bahal' lands are nearly equal in area and together account for about 30% of the total commanded area. They are particularly suitable for growing paddy, and can yield a successful crop without irrigation in years of good rainfall. But in dry years or with uneven distribution of rainfall, irrigation is beneficial to paddy even on these lands. Generally, speaking the cultivators have to face the prospect of having once in three or four years a rainfall below the minimum compatible with the ripening of crops or of suffering a loss of one-fourth to one-half of the rice in the unirrigated lands.

Carefully prepared 'At' and 'Mal' lands near the *abadi* (village site) with irrigation facilities from tanks or wells are known as 'Barchha' and 'Bari' lands. The area under these is hardly about 2%. Sugarcane is usually grown on these lands in alternation with wheat, gram, potatoes or vegetables. At places, fine orange or mango gardens have been established on 'At' lands. Water is the chief need of these lands and with water becoming available the lands offer great potentialities for intensive cultivation and rich harvest. At present, for lack of irrigation during winter and summer, less than 5% of the area is double-cropped.

The most common source of irrigation in this area is the tank. The tanks are of two types. The bigger tanks locally known as 'Kata' are formed by an earthen embankment thrown across the drainage area. These supply water securely to at least 5 acres. Usually each of these tanks has an area of 30 to 200 acres to irrigate. The small tanks called 'Munda' ordinarily irrigate less than 5 acres and do not provide secure irrigation. Irrigation of

'Bahal' and 'Berna' lands is easier than of 'Mal' and 'At', which are high and medium high lands. The proportion of 'At' land under irrigation is negligible but it is the highest in 'Bahal' lands. 'Mal' and 'At' lands which require water more than other lands are practically starved at present. Tank irrigation cannot on any account be called secure. A sample survey was conducted in 125 out of 795 villages in the commanded area and it was found that only in 13 villages or roughly 10 per cent of the villages surveyed, the lands irrigated from tanks, wells, etc., were fully secured against drought. The remaining irrigated area did not get secure water supply as the 'Katas' and 'Mundas' are fed only by rains and in years of short rainfall their capacity is too inadequate to water the lands. So a good deal of the area recorded as irrigated by tanks in the commanded area of canals is really not fully irrigated.

Characteristic Agricultural Features of Delta Zone

The Mahanadi Delta is a wide alluvial plain with a network of river channels. It covers large portions of the Cuttack and Puri districts. The soil is composed of sand and silt varying in proportion according to its formation, i. e., the proportion of sand increases as we reach nearer the sea. The soil is generally very fertile and produces good crops in normal years.

The bulk of the delta area being flat is subject to floods. The annual rainfall is about 60" but it is not very regular. Untimely rain or its unequal distribution has often caused wide-spread crop failures. Some showers are necessary in February or March to enable the lands to be ploughed but often the ploughing is delayed because of a continuous spell of dry weather. The most critical months are June, September and October. Sowing is abnormally delayed and the success of paddy crop is affected considerably if monsoon

showers do not fall in June and the crop is totally ruined for want of a few inches of rain in September and October. The most terrible famine of 1866 occurred due to the failure of rains in September and October and in 1896 and 1907 serious loss was caused by such failure though the total rainfall in the years was only slightly below the normal. Serious damage to crops occurs on an average twice every five years either on account of floods or drought.

The principal crop is rice, chiefly the autumn and winter variety. Summer rice is grown in a very limited area. In the year 1952-53, autumn and winter rice were grown respectively on 1,51,700 acres and 11,39,100 acres in the Cuttack district and 37,800 acres and 8,55,700 acres in the Puri district. The area under summer rice was 16,000 acres in Cuttack and 7,700 acres in Puri. Other crops grown in these districts are maize, millets, pulses, gram, *til*, castor, sugarcane, coconut, *pan*, tobacco, potato and vegetables. The delta is excellently suited for jute cultivation. The area under *rabi* pulses has of late shown a tendency to increase. It has risen to about 17% of the total cultivated area in Cuttack and Puri against 12% found at the time of the last settlement. The area under oil seeds in the two districts is at present about 65,000 acres *i. e.*, more than 2.5% as against less than 1% during the last settlement. *Til* (*Sesamum*) is the principal oil seed and seems to be gaining popularity. Groundnut has not made much headway in to Puri district but about 7,000 acres have been put under this crop in the district of Cuttack. Cotton growing dwindled into complete insignificance during the last settlement and there were only 246 acres under this crop. This area has since increased to about 6,000 acres in the Cuttack district and about 400 acres in the Puri district. Jute was grown over 5,080 acres in all the coastal districts of Cuttack, Puri and Balasore during the last settlement; at present the area in the Cuttack district alone is 68,000 acres.

Sugarcane was found only on 4,525 acres during the last settlement in all the three coastal districts but at present the area in Cuttack and Puri alone is about 17,000 acres. Another crop which has gained much popularity in recent years is potato, of which there was no mention in the last settlement report. It is now widely grown in the districts of Cuttack and Puri, the area in 1952-53 being 14,000 acres in the district of Cuttack and 1,676 acres in the district of Puri. Cultivation of wheat has gained some popularity and about 3,000 acres were under this crop in the Cuttack district in 1952-53. The area in the Puri district was negligible being only 32 acres. The cultivation of cash crops like jute, sugarcane and potato is gaining favour with the cultivators but this has not been done at the expense of paddy cultivation except in the case of sugarcane. In the canal areas of Salepur and Kendrapara thanas, soon after the harvesting of jute, the land is put under transplanted paddy; potato is grown mostly in the well-drained autumn-rice lands after the rice crop is harvested.

Areas growing more than one crop a year in the Cuttack and Puri districts in 1952-53 were respectively 3,48,800 acres and 2,47,335 acres. The proportion of double-cropped area to the total cultivated area was 23 per cent in Puri and 27 per cent in Cuttack. The proportion in all the 3 coastal districts during the last settlement was 11 per cent and it is evident that the area under double-cropping has increased more than two fold during the last 20 years. Double-cropping depends on lift irrigation. Water is lifted mostly by manual labour.

The existing source of irrigation is the network of canals constructed in the delta area in the nineties of last century. The total length of canals is 205 miles both for irrigation and navigation and 75 miles for irrigation only, besides nearly 1,100 miles of distributaries and village channels.

A major part of this canal mileage, *i. e.*, 240, is in the Mahanadi delta.

The average area irrigated during the 10 years 1942—52 works out to only 1,95,000 acres or roughly 48 per cent of the commanded area. The total area under *rabi* on the three canal systems was about 77,000 acres or roughly 19 per cent of commanded area. The average annual intensity of irrigated area during both *Kharif* and *Rabi* seasons thus amounted to only 67 per cent. This is due to the unsatisfactory running of existing canals. Due to the absence of water-courses there is a lot of wastage of water and inequitable distribution. There is no canal irrigation in the Puri district. Artificial irrigation is done from various sources, *viz.*, rivers, streams, tanks and wells in areas where there are no canals. After the rains stop, water is lifted for irrigation from *nullahs*. At places water is carried by labourers in earthen pots over a considerable distance. Coconut cultivation suffers due to lack of water. Young coconut plants require watering in dry weather for the first one or two years.

Benefits from Irrigation

Most of the river valley projects are located in arid or semi-arid zones where rainfall is scanty and irrigation constitutes the life-blood of farming. The Hirakud Dam Project is, however, situated in a humid region with an annual rainfall of 54" to 60". Naturally there have been questions about the utility of the project for the purpose of irrigation in an area with such a high rainfall. Most of the doubts expressed are based on the assumption that the region, as at present, will remain a single-cropped region with rice as the major crop occupying 73.6% of the total cultivated area, as much as 99.2% of which is grown as autumn and *sarad* crop and depends for its success on rain. It has not been appreciated that, with irrigation, cultivation of *rabi* crops will extend

over large areas, perhaps because, for centuries, the agricultural economy of Orissa has been identified with paddy. *Rabi* cultivation over any large tract has been practically unknown. The long association of people with paddy seems to have created a feeling in them that paddy alone can be grown on any large scale in Orissa. Some even argue that extension of area under *Rabi* is not possible and cite the example of the Cuttack district where irrigation has been in existence for about a century and yet, as they say, the area under *Rabi* crop has not increased at all. This is however, not quite correct. It has already been stated that there has been an increase in the area under *Rabi* cultivation in Cuttack. Further, if the area under *Rabi* crops has not gone up significantly, it is simply because the canals are not perennial and do not supply adequate water for irrigation during *Rabi* and summer seasons. The canals are designed for a flow of 4,100 cusecs but the flow in the Mahanadi is reduced to 300 cusecs only during the summer.

Fortunately, only a few who are not directly concerned with farming, question the utility of irrigation. The importance of irrigation is very well understood by the farmers. There is no doubt that irrigation in Orissa heralds a new era of agricultural development and will lead to the following benefits.

Increase in Double cropped Area

It is abundantly clear that the soil and climate, in both the Sambalpur and Delta zones, are quite suitable for the cultivation of *Rabi* crops. In addition, crops which are grown in *Kharif* elsewhere, e. g., cotton, groundnut, *mung* and summer crop of paddy can also be grown here in *Rabi*. Even at present, wherever water is available for irrigation during October to June, farmers are raising fine crops of sugarcane and vegetables in both Sambalpur and Delta areas although water

has to be lifted by manual labour. In the Delta, the percentage of double-cropped area is much larger.

Experiments at the Central Rice Research Station, Cuttack, have successfully demonstrated that under canal irrigation two crops of paddy can be easily raised with a total yield of about 40 mds. per acre. The average yields of some of the *Rabi* crops obtained at this Station, in its crop sequence experiments in 1953-54 and 1954-55, were as follows :—

TABLE

Sl. No.	Rabi crops	Mean yield of grain in lbs. per acre
1.	Rice (summer)	1393
2.	Wheat	505
3.	Groundnut	1267
4.	Cotton	538
5.	Mustard	129
6.	Mung for green manure and rice	1857
7.	Mung for seed	289
8.	Dhaincha & rice	2193
9.	Linseed	274
10.	Gram	1217

So far, irrigation has been the only limiting factor in the extension of double-cropping in both the areas. The 'At' and 'Mal' lands which account for more than two-thirds of the total land surface in the commanded area in Sambalpur zone

are not able to retain moisture. In the Delta, the soil being well-mixed up with sand in wide areas, requires water frequently in the dry weather and, without an assured supply of water, extensive double-cropping is not possible.

Thus, there is positive evidence available both on farmers' holdings and on the research farm in support of the fact that *rabi* crops can be quite successfully grown in both the areas.

With perennial irrigation, an intensity of 150 per cent is expected in the Sambalpur zone and 177 per cent in the Delta zone as indicated below :—

1. The Sambalpur Zone

Right and left side flow canal

<i>Kharif</i> —	<i>Kharif</i> paddy and other <i>Kharif</i> crop	90 per cent.
	Sugarcane	10 per cent.
<i>Rabi</i> —	<i>Rabi</i> paddy	30 per cent.
	Cash <i>rabi</i>	15 per cent.
	Light <i>rabi</i>	5 per cent.
		—
		150 per cent
		—

2. The Delta Zone

(a) *Kharif*

Intensities
per cent

(i) Jute	15	
(ii) Aman paddy	80	(This includes 10 per cent of the land in which jute will be grown)

(iii) <i>Beali paddy</i>	5	To be followed by vegetable and potatoes in winter.
(iv) Sugarcane and garden	10	
	110	
(b) <i>Rabi</i>		
(v) <i>Dalua paddy</i>	12	
(vi) <i>Wheat, cotton & groundnut</i>	10	
(vii) <i>Cover crop (legume variety)</i>	40	
(viii) <i>Vegetable and potatoes</i>	5	These will be grown in <i>Beali paddy</i> area.
	67	
Total intensity during the year	177	

The farmers of the area, particularly in Sambalpur, have no previous experience of growing *rabi* crops. They also lack finance for investment on improvement of the land and for meeting the additional cultivating expenses. Yet the area under *rabi* will expand considerably as soon as irrigation becomes available. No doubt the State has to play an important role in this direction, but the experience of development in other areas after the introduction of irrigation facilities lends support to the belief that the farmer in the Sambalpur Zone as well as the Delta zone will not wait for the Government to provide them the facilities. They will go ahead with their programmes of *rabi* cultivation and land improvement. This does not, however, minimise the need of State aid, agricultural research and extension in accelerating the pace of development.

Agricultural Research Station, Sambalpur

The State, too, is ready to play its role. An Agricultural Research Station has been established at Sambalpur with the object of evolving and testing new and improved varieties of crops and evolving suitable crop rotations and manurial, cultural and irrigation practices for the commanded area under the project. A comprehensive programme of research has been drawn up including work on vegetables and fruit crops. The results of research at this station will come very handy to agricultural extension workers in the area. For the present, very little experimental data are available on varieties, crop sequences and manurial, cultural and irrigation practices suitable for the canal area. The Research Station will, indeed, play a vital role in guiding agricultural improvements on the right lines in the area. A community development block has also been opened in the Baragarh division to educate the farmers in better methods of farming.

At this stage, it is difficult to give even an approximate idea of how the area will be distributed under different crops, *i.e.*, second crop of paddy, sugarcane, cotton, groundnut, wheat, oilseeds, etc. The farmer will be guided mainly by the profit motive and the expansion, howsoever gradual it may be, will be in favour of cash crops, *e.g.*, sugarcane potato, etc. The yield of sugarcane is about 15 to 20 tons per acre *i.e.*, about 50% higher than that in Northern India, although it is lower as compared with the South. This further ensures a swing in favour of sugarcane cultivation; the estimate of 10% under sugarcane may prove to be an underestimate. As against growing of one crop in the year, mainly paddy, irrigated farming will enable farmers to follow many new rotations and increase the intensity of cropping on land leading to its fuller utilization. Some of the rotations that will become popular are (i) paddy-pulse, (ii) paddy-moong.

(iii) jute-paddy, (iv) early paddy-wheat, (v) green manuring-paddy, (vi) green manuring wheat, and (vii) groundnut-sugarcane-ratoon.

Greater Security to Paddy Crop

Irrigation is no doubt essential for growing *rabi* crops but it is also necessary for successful raising of *kharif* crops, particularly paddy. One cannot be sure of a full crop of paddy without irrigation. Rainfall, however well-distributed it may be, can hardly meet such regular requirements as paddy has for water. The crop gets damaged and the yield goes down considerably if the moisture supply is deficient in the field and rains get delayed even by a period of ten days. Paddy is the major *kharif* crop in both Sambalpur and Delta zones. The precarious nature of the precipitation even during the monsoon and its unequal distribution bring hazards to the paddy crop. Mr. Maddox in his settlement report of the Delta area, has, after analysing figures for a considerable period, come to the conclusion that cultivators face the prospect of crop failure once in every 3 or 4 years and generally lose 1/4th to one-half of the rice crop in the unirrigated lands. Since the volume of export in any one year is dependent on the production of rice in that year, some idea of the wide fluctuations in the production of rice in the State can be had from the export figures of rice during 1943-52 given below :—

Years	Export of rice in thousand tons
1943-44	6,26,260
1944-45	81,951
1945-46	84,911.1
1946-47	1,25,147
1947-48	1,40,836.4
1948-49	1,27,700.29

Year	Export of rice in thousand tons
1949-50	1,11,043'0
1950-51	14,551'56
1951-52	1,16,537'41

In three years out of nine, the export of rice has been far below the average.

In the Sambalpur zone, on the low-lying 'Bahal' and 'Berna' lands, there is a reasonable prospect of a good paddy crop without irrigation but canal irrigation will ensure a *full crop* against partial failure or uneven distribution of rain.

Increased Production

After a detailed examination, the Sivraman Committee (1953) estimated an increase of the following order in the yield of paddy on different classes of land in the Sambalpur zone :—

	Present average	Probable increase
	mds.	mds.
Bahal	22	26½
Berna	16	21
Mal	10	18
At	6	16

These estimates are somewhat on the conservative side. With full development and facilities of manure, good seeds, etc., the actual increase in the yield of paddy is bound to be higher.

In the Delta, the average yield per acre of paddy in irrigated areas is usually 5 maunds higher than the yield from unirrigated lands. This has been proved by the crop-

cutting experiments carried out annually by the officers of the State Public Works Department. The results of crop-cutting experiments for the 11 years from 1917-18 to 1929-30 (with the omission of the year 1919-20) have been tabulated in Mr. Dalziel's settlement report of 1932 and show that the difference in yield of paddy per acre between irrigated and non-irrigated land is more than 6 maunds. An acre of irrigated paddy land also gave about 10 maunds or 2 cart loads more of straw. The experiments performed by the Settlement Department during the last settlement yielded slightly different results and according to these experiments, the difference in the yield of paddy was about 4 maunds. An estimate of 5 maunds may be accepted as a safe variation in yields per acre between irrigated and non-irrigated lands.

The Sivraman Committee has come to the conclusion that there will be an increase of about 57 lakh mds. and 50 lakh mds., in paddy production each year in the Sambalpur and Delta zones respectively as a result of introduction and intensification of canal system in both these zones. These estimates have been drawn up on a modest and conservative basis. No estimates of increase in production of *rabi* crops have been made as it is too premature to forecast the distribution of area under various *rabi* crops, but there is no doubt that there will be considerable expansion in the production of *rabi* crops in both the areas.

Better Farming

Another important point to which attention needs to be drawn is that irrigation not only leads to double-cropping but also to better farming. Lack of irrigation has been the main difficulty in the adoption of improved practices in agriculture. With an assured perennial irrigation, many agricultural improvements will follow in the wake. The most

important among them will be the application of manure at an increasing rate. With the availability of irrigation water in early May and June, the practice of green manuring for paddy is likely to be adopted on a wide scale. Fertilizers and other manures will also be used increasingly. Sowing of crops early and well in time without waiting for the monsoon shower will be another important change in the agricultural practice. Timely or early sowing of crops makes considerable difference in the yield of crops. The yield of transplanted paddy is higher than that of the broadcast paddy. With irrigation, there will be increase in the area under transplanted paddy. Presently nursery sowing is not practised because of lack of irrigation facilities during the months preceding the rainy season.

Security of Income

The introduction of perennial irrigation in these areas will ensure, for the first time, security of income to the farmers who can be assured of a prosperous future. Benefits in terms of human happiness and improvement in morale will be such as cannot be measured.

No Water-Logging

There is no danger from water-logging with canal irrigation, as experienced in other regions. It has already been stated that the central table-land comprising the Sambalpur zone possesses good drainage. Investigations carried out by the Hirakud Research Station have confirmed that there should be little danger of water-logging in the major portion of the area.

No Harmful Effects due to Accumulation of Salts

The total solids dissolved in the Mahanadi water range from 8 to 26 parts per 100,000 parts of water. Out of the acidic ions, the bicarbonates are the most predominant,

phates and chlorides being less in comparison. Watersul containing less than 60 parts dissolved solids per 100,000 parts of water is normally considered safe for irrigation purposes. Judged by that standard, the Mahanadi river water is safe for irrigation and little salinisation of land is expected by the application of that water due to the preponderance of calcium salts. This position is confirmed by the fact that the use of the Mahanadi water for irrigation in the Delta Canal System for over 80 years in the past has not caused any marked soil deterioration in the area under command.

The high rainfall combined with the good draining capacity of soil will counteract any harmful effects due to accumulation of salts in the area.

Deposit of Silt

The fields in the Delta were being enriched by the deposits of silt after floods. With the implementation of the project, there will be a reduction in the amount of silt deposited in this area. Since the supply will be limited to periods of heavy rains when the fields are inundated by the river water. Canal irrigation in the Sambalpur zone, however, will result in greater supply of silt to the farmer's field and thus be a direct source of improving particularly the 'At' and 'Mal' lands which have been continually losing their valuable top soil through years of neglect.

Soil Conservation

A secure income brought about by irrigation will lead to investment on land improvement and its careful cultivation. The land will be under one or the other crop throughout the year with the result that losses through soil erosion will be reduced to the minimum, especially on 'At' and 'Mal' lands, in the Sambalpur area. Gradually, these lands will also turn into rich and fertile fields.

Prosperity in General

The increase in agricultural production, more secure yield and change from single-crop farming to diversified and intensive farming will create considerable opportunities for employment not only for the sons of farmers, in the sense of round-the-year work, but also to a large labour force as agricultural labourers, and in transport and trade. The expansion of area under sugarcane, cotton and groundnut will lead to the establishment of sugar factories, textile mills and hydrogenerated oil mills. All this will add to the volume of employment and thereby to the prosperity of the people in general. A chain reaction of improvements will start and the development in agriculture will have to be seen to be believed. This has happened elsewhere with the advent of irrigation and is bound to be the experience in Orissa as well. So far as *Rabi* is concerned, Orissa hardly differs from other regions. There too, water had been a limiting factor. The additional advantage with Orissa is that, besides the commonly grown *Rabi* crops, it can also grow during *Rabi* a second crop of paddy, cotton, groundnut, etc. which are cultivated only as *Kharif* crops in many parts of India.

POWER—ORISSA'S OPPORTUNITY

Just as absence of irrigation has been responsible for holding up the progress of agriculture in Orissa, similarly its rich mineral resources have remained undeveloped for lack of power. Indeed, Orissa is the most undeveloped State in the Indian Union with the lowest per capita consumption of 0.29 kWh of electricity as against 9.2 kWh for the whole country. In 1952, the total installed capacity of electricity in the State was only 4,845 kW. On the completion of Stage I, the project will contribute 1,23,000 kW to the total installed capacity, i.e., about twenty five times the entire installed capacity in the State. With the completion of Stage II, by 1960, another 1,09,500 kW will be added bringing the total installed capacity to 2,32,500 kW. A kilowatt-hour is estimated to be the equivalent to 10 hours of human energy. The supply of power of 1,30,000 kW at 100% L. F. which amounts to 1138.8 million kW hours is, therefore, equivalent to 11,388 million man-hours. The Project thus makes available to the people of Orissa this enormous amount of energy to mould their destiny in a new manner.

At the time the proposals for the Project were under formulation, it was felt that it would take a long time for sufficient demand to develop for the utilization of such a large quantity of power. The total industrial demand was estimated at 30,000 kW only which has now been booked by the one-million ton Hindustan Steel Factory alone. The ultimate

requirement of the steel plant and subsidiary industries there is estimated at 60,000 kW and to meet this and other developing loads, the completion of Stage II, of the Project for the generation of additional power has become an immediate necessity.

In the beginning, in all the major river valley projects, a certain amount of uncertainty existed regarding the full utilization of huge quantities of electricity generated. But everywhere the experience has been that the demand has out-stripped the production of power. It has proved just as true in the case of the Hirakud Dam Project as well. Even before the generation of electricity from the project, there has developed sufficient demand for its entire output. As a matter of fact, it has become necessary to increase the production of power in the state in order to meet the demand already in existence.

Generally, the multi-purpose projects are located in backward areas. As the inhabitants in the area are poor and un-progressive, the planners feel that the pace of development is bound to be slow. But contrary to this belief, it is exactly in such areas that the potential demand for power is high. As soon as the twin forces of progress, *i. e.*, irrigation and power are released in the service of man, the development of the area is so quick that even the optimists are surprised at the speed of development.

The Hirakud Dam Project area is also one of the most undeveloped tracts of the country with people suffering from abject poverty [REDACTED] floods. There has been little industrial development in the [REDACTED] in spite of its rich mineral deposits. But the developments that have recently started even before water and power became available, have fully justified the faith of people in the multi-purpose Hirakud Dam Project. A new township at Rourkela is growing up fast. The preliminaries.

are in hand for a 10,000 ton Aluminium Factory at Hirakud. The blue prints of a number of other industrial concerns are ready for implementation.

By 1960 power generated in the Hirakud Power Houses will be utilised in the various industries as detailed below:-

		kW		
Aluminium.	50,000	Mining Loads (Barabil, Birmitrapur and Rairangpur)		
Steel	60,000		8,000 kW	
Ferro-manganese	20,000	Colliers	2,400 kW	
Cement	5,000	Cuttack and other Rural and town		
Paper	3,000	Loads	13,000 kW	

Power will be generated at 11. kV and will be stepped up to 132 k.V. before being conveyed through H. T. Transmission lines to different consuming centres.

The Transmission system comprises of the following lines:-

- (1) One single circuit 132 kV line from Hirakud to Chowdwar (5 miles from Cuttack).
- (2) One double circuit 132 kV line from Hirakud to Rourkella.
- (3) One double circuit 132 kV line from Power House to Aluminium Factory at Hirakud.
- (4) One single circuit 132 kV line from Rourkella to Joda.
- (5) One single circuit 66 kV line from Joda to Kuldaha.
- (6) One single circuit 66 kV line from Joda to Koira.
- (7) One single circuit 66 kV line from Hirakud to Bargarh.

The demand for power is expected to rise still higher, With the development of some basic industries in the area, there is bound to be considerable growth of allied and subsidiary industries. At present industries to be developed or already developed or in the process of development in the area are:-

- (i) Aluminium Factory at Hirakud.
- (ii) Ferro manganese plant at Joda.
- (iii) Hindustan Steel Ltd. at Rourkela.
- (iv) Paper Mill at Chowdwar and Brajraj Nagar.
- (v) Cement Factory at Rajgangpur.
- (vi) Textile Mills.
- (vii) Sugar Mills at Bargarh.
- (viii) Tube mill at Chowdwar, and
- (ix) Development of mines and collieries.

There will be subsidiary industries around all these new industries. Moreover, cottage industries particularly the local textile industry will, in all probability, be remodelled with the help of cheap electricity. Many townships will also grow and the demand for lighting and other domestic purposes will go up. Besides, there will be many opportunities to refashion life with cheap electricity.

Extensive exploitation of the States mineral resources hitherto lying untapped will change the very face of the State. People will have more and more employment. The 'per capita' income will go up. There will be considerable stimulus to trade and transport services, building and construction works' and economic and social activities. In short a new era of all round prosperity and development will be established in Orissa.



CHAPTER IX

OTHER BENEFITS FROM THE PROJECT

Pisciculture

The huge reservoir extending over 233 sq. miles provides ample scope for the development of fisheries. A scheme has been drawn up for stocking and experiments in power fishing in the reservoir. Special nurseries will be constructed below the dam for stocking and rearing the spawns to a large size. From there the fish will be transferred to the main reservoir. Experiments in power fishing in inland waters have not been carried out so far in a systematic manner in India. This scheme will provide first hand experience in this respect. The expected receipt in the experimental period is estimated at Rs. 10,000 annually.

Scenic Beauty

The dam and the huge expanse of water in the reservoir with a pleasant motor drive on the top of the dam and dykes provide a place of attraction to the visitors. It is also proposed to develop a beautiful garden downstream on the Hirakud island. It will make the place still more attractive. Many other sites on the river bank can be developed for their scenic beauty and as centres of rest and recreation for the tourists. One such site will be at Chiplima where the subsidiary power house will be located. There is a need for a systematic survey of the sites which can be developed as beauty spots on the bank of the river during its long course before it enters the Delta.

Employment

The Project, during its construction, has provided employment to a large number of skilled and unskilled workers. Their total contribution exceeds 5.77 crore man-days. The shift from concrete to masonry dam made the Project highly labour intensive.

At peak working, about 10,000 workers were under the direct employment of the Project authorities as operators, fitters, riggers, carpenters and various other categories of skilled and unskilled labour. Besides, the contractors' labourers numbered about 20,000. The total labour utilization on the project, on a rough calculation, is equivalent to the employment of 25,000 labourers for eight years. The excavation of canals and water courses provided a good source of additional employment and income to people in the villages situated in the commanded area. They were able to earn in wages larger amounts than what they had to pay as betterment levy due to the introduction of canal irrigation. But this benefit accrued only where the water courses were constructed departmentally. Even on payment of higher rates to farmers, the departmental construction of water courses was found cheaper than through the agency of contractors.

On completion, the Project will provide employment to engineers and skilled and unskilled workers needed for proper supervision, operation and maintenance of various works under the Project.

The indirect rise in the total employment provided by the increase in the general economic activities of the Project area is, however, difficult to visualise at this stage.

Road, Railways and Rail Road Bridge

The Mahanadi in all its course of 533 miles did not have a road bridge across it. The construction of a rail-road bridge across the river near the Project headquarters was completed in 1950 for the transport of heavy plant and machinery and for large construction operations in the Project. The bridge consists of 25 spans of 100 feet each and is more than half a mile long. The roadway is 24' wide with 5 foot-paths on either side. The National Highway from Calcutta to Bombay passes through Sambalpur. In order to link it with the project headquarters, ten miles of cement road on either side of the rail - road bridge was constructed. The project has 3,752 miles of broad gauge railway with 12 locos and 534 open wagons for the movement of construction material to various points on the project works. The Hirakud Dam Railway is linked to the "South Eastern Railway" at the Sambalpur terminus.

Indirect Benefits

There will be a general expansion in the economic activity resulting in increased employment, larger volume of business and higher income and better standard of living. All this will lead to considerable social improvements and greater facilities in the form of education, sanitation and medical relief. In brief, the people of the Project area will lead a fuller and richer life.

The Centre and the State too will have their share of benefits in the form of increased income from various taxes, e.g., income tax, postal and telegraph charges, railway fare for both passenger and freight service, land revenue and sales tax. It is like a chain reaction, the Project has aroused the latent energy of the sleeping Orissa public and there is an around awakening resulting in the betterment of economic and social conditions of the people of Orissa.

Navigation

Due to its high cost, the proposal for navigation has remained unimplemented, but the Mahanadi possesses rich potentialities for development in this direction. Orissa is very poorly served in respect of means of communication and transport. Numerous river channels and drains make the construction of roads a very costly affair in the Delta. Therefore, if navigation can be developed it will fulfil one of the needs of the state, i.e., of augmenting the transport facilities to handle the increasing volume of goods both industrial and agricultural as a result of rapid industrialisation and agricultural development brought about by the Hirakud Dam Project.

CHAPTER X

RESETTLEMENT OF THE DISPLACED

The problem of resettlement and rehabilitation of the population displaced by the submergence of usually a large area of land under the reservoir formed by the damming of the river is common to all the multi-purpose river valley projects. The reservoir in the Hirakud Dam Project submerges an area of 288 sq. miles

It involves submergence of 249 villages in the Sambalpur district and 34 in Madhya Pradesh—113 fully and the rest partly. The total area of land lost is 1,82,592 acres of which about 1,23,000 acres were culturable. This has given rise to the problem of finding new homes and new lands for about a lakh of people. However, taking into consideration the large area submerged under the reservoir, the number of villages submerged and people displaced is not at all high. Fortunately, much of the land that has been submerged was hilly and under forests.

Hirakud Land Organisation

A new department under the name of 'Hirakud Land Organisation' was set up by the State Government for orderly evacuation, resettlement and rehabilitation of the displaced persons. The appointment of separate officers for land acquisition, land reclamation and resettlement under the immediate charge of a Deputy Commissioner, Settlement, has ensured a smooth working of the organisation from the very

beginning. Each of the three officers, (i) the Land Acquisition Officer (ii) the Land Reclamation Officer and (iii) the Settlement Officer, has clearly defined responsibilities. This has enabled the work to be disposed of efficiently and speedily. The Member, Board of Revenue, Orissa, at Sambalpur is in overall charge of the Organisation.

The duties of the Land Acquisition Officers are to determine the amount of compensation and make payments to displaced persons for their land, houses, trees, etc. An additional Land Acquisition Officer deals with compensation claims for properties acquired for the excavation of the canals.

The Land Reclamation Officer, Assisted by an Executive Engineer is responsible for ~~clearing~~ ^{clearing} the forest area by mechanical operations. The jungle is cleared and the land levelled and marked into agricultural fields.

The Resettlement staff is responsible for evacuation, and receipt of deposits for land and settlement of people on the reclaimed land. It consists of a Resettlement Officer, an Agricultural Officer and a Medical Officer and their Assistants. This is, in brief, the organisational set-up of the Hirakud Land Organisation.

Payment of Compensation

Compensation in the case of *Bhogra* lands which are zamindari lands and saleable has been on the basis of market price. The compensation for *Royati* land was paid on the basis of multiples of deduced rent. The deduced rent was calculated for each parcel of land after taking into consideration the standard rent, soil factor and village conditions. The land in Sambalpur was divided into 32 classes. Each class was allotted a soil factor in the settlement. The lowest class of

land, namely 'At' (Upland) was allotted a soil factor of 2 whereas the highest class of land, i.e., 'Barchha' (Sugarcane field) was allotted a soil factor of 50. These soil factors represented the relative fertility and yield of the land. Again, each village was allotted a unit rate ranging from 50 to 100 in consideration of the soil conditions, situational advantage, irrigation facilities and the revenue assessed on the village. Before assessing compensation, improvements made by the landlord or tenant since the last settlement operation, which took place 25 to 30 years back, were taken into consideration. The settlement rates were not down-graded even if the land had deteriorated.

In the case of service land, the persons holding it were prevailed upon to take land in exchange in the reclaimed area, the idea being that the village service personnel from the submerged villages may be settled in the new villages.

Compensation for waste land was usually assessed at nominal rate which ranged from one third to one half of the compensation for 'At' land.

Compensation for fruit trees was assessed separately in consideration of their yield, the number of years during which the trees would be expected to bear fruits, the vicissitudes of the season, the liability to destruction and uncertainty of income. Compensation for timber trees and fuel trees was assessed in consideration of the timber value or wood value. The multiples for compensation of land varied from 360 to 625 of the deduced rent and the highest price paid per acre was about Rs. 900. The rate of compensation was very favourable and the displaced persons have been able to get a much larger area of government reclaimed land for the cash compensation for their land. The total compensation payable for the entire area is estimated to be Rs. 8.64 crores.

Resettlement

The policy adopted in resettlement was to give land for land and construct in the newly settled villages grain *golas*, temples, Bhagabatghar, village schools and hospitals as existed in the submerged villages or as was dictated by the needs of the settlers in their new surroundings. Irrigation tanks and village tanks have also been constructed in the newly settled area. For meeting the cost of settlement and payment of compensation to individuals, the compensation has been worked out for individual as well as common property, *i.e.*, the village temples, tanks, etc. in the submerged area. The entire amount of compensation so calculated is charged to the project and from this amount is met the cost of construction of tanks, temples, etc., in the newly-settled villages.

Originally, it was planned to reclaim 80,000 acres of land for the settlement of people from the submerged area. But on actual experience, it was found that most of the people preferred to settle in old established villages to taking land in the reclaimed area. Therefore, the target for land reclamation fixed in the beginning has been reduced. Due to the sudden demand for land in the old established villages, the local land values increased and this upset to some extent the advantage of liberal compensation rates in the case of displaced persons desirous of purchasing land in the old established villages. In many instances they could purchase only less land than what they owned in their villages.

However, it was a matter of free choice with them, *i.e.*, they could purchase land on their own or they could deposit money with the Resettlement Officer and get land from him in the newly reclaimed area. The average rate per acre charged for the land in the reclaimed area was about Rs. 200 to Rs. 250.

As stated above, large numbers of the people from the submerged area have settled in the old established villages and the demand for land for settlement in the newly reclaimed area is much smaller than was originally expected. This has made the task of Hirakud Land Organisation easier. It was found from the figures of evacuation in 1954-55 that about 11% of the land owners from the submersion area came to Government reclaimed land and the rest made their own arrangements. This has also been the experience elsewhere. In DVC, out of 4,602 families affected by the Maithon reservoir 650 families desired to be settled and the rest preferred cash compensation. Generally, the bigger land-holders have settled in old villages but the small land-holders have moved to the Government reclaimed lands.

The other factor which helped the resettlement of displaced families in the old villages was that the land was available for sale in these villages. The land legislation enacted in Orissa, in 1953 conferred saleable rights on the occupancy tenants and limited the individual holdings to 33 acres. Therefore, many of the farmers who had no right to sell land, acquired this right and sold their surplus land to the people from submerged area who made cash payment from the compensation money received by them. Land-holders possessing more than 33 acres of land were also anxious to sell part of their land.

The settlers were given house sites free of cost. Timber and other house building materials were supplied at concessional rates. The Agricultural Development Officer and his staff provide necessary guidance to the settlers in respect of cropping programmes, manuring and cultivation practices on the newly reclaimed land. Chemical manures were supplied free in the first year. The first ploughing of land was also done free, where needed with the help of tractors.

The Agriculture Officer also arranges for the crop protection services. The Medical Officer visits the newly settled villages and gives free medical treatment to the people. A number of irrigation and village tanks, wells and schools have been constructed in the reclaimed area.

The evacuation started in the summer of 1955. Free transport was provided to all the people to carry their personal effects including their paddy and other foodstuffs. The authorities were really faced with a formidable task. It needed all the ingenuity and human skill to make the evacuation as peaceful and as little painful as possible and the officers, unmindful of their personal inconveniences, made every effort to meet to the utmost the just desires of every displaced person. Their task was, however, not over after evacuation. They had to face all sorts of real and imaginary complaints of the settlers regarding allotment of house sites, land, construction of tanks, temples, schools, etc. The Resettlement Officer was required to select the area for resettlement and the site for villages, temples, tanks, etc. in consultation with the people of the submerged area who were to be settled there. It was not always easy to satisfy every one but the problems were solved with unusual sympathy and most of the genuine grievances were redressed. Sometimes, the settlement Officer had to face demands such as providing the new village with a *pujari* to worship the village deity as the *pujari* from the submerged village did not accompany the settlers and went to some other place. But efforts were made to fulfil even such demands.

The uprooting of people from their centuries-old abodes was by no means an easy task. Apart from disturbing their well-settled economy and peaceful life, the question of sentiments was involved. The people of the submerged area were very unsophisticated. They had been able to maintain solidarity of the village community organisation intact. Each

village had its own deity and *Bhagbatghar*, where people gathered to recite religious books or hear religious discourses. Modern civilization had affected their lives very little. So it was unthinkable for them to leave their villages which also meant leaving their deities. But once they knew that there was no alternative but to move in time before every thing that they loved, the rich paddy fields, the groves, the deities, the tanks and the wells got submerged, the very organised community life, which made people resist in the beginning the demand for leaving their villages helped in their most orderly evacuation.

CHAPTER XI

THE ORGANISATIONAL SET UP

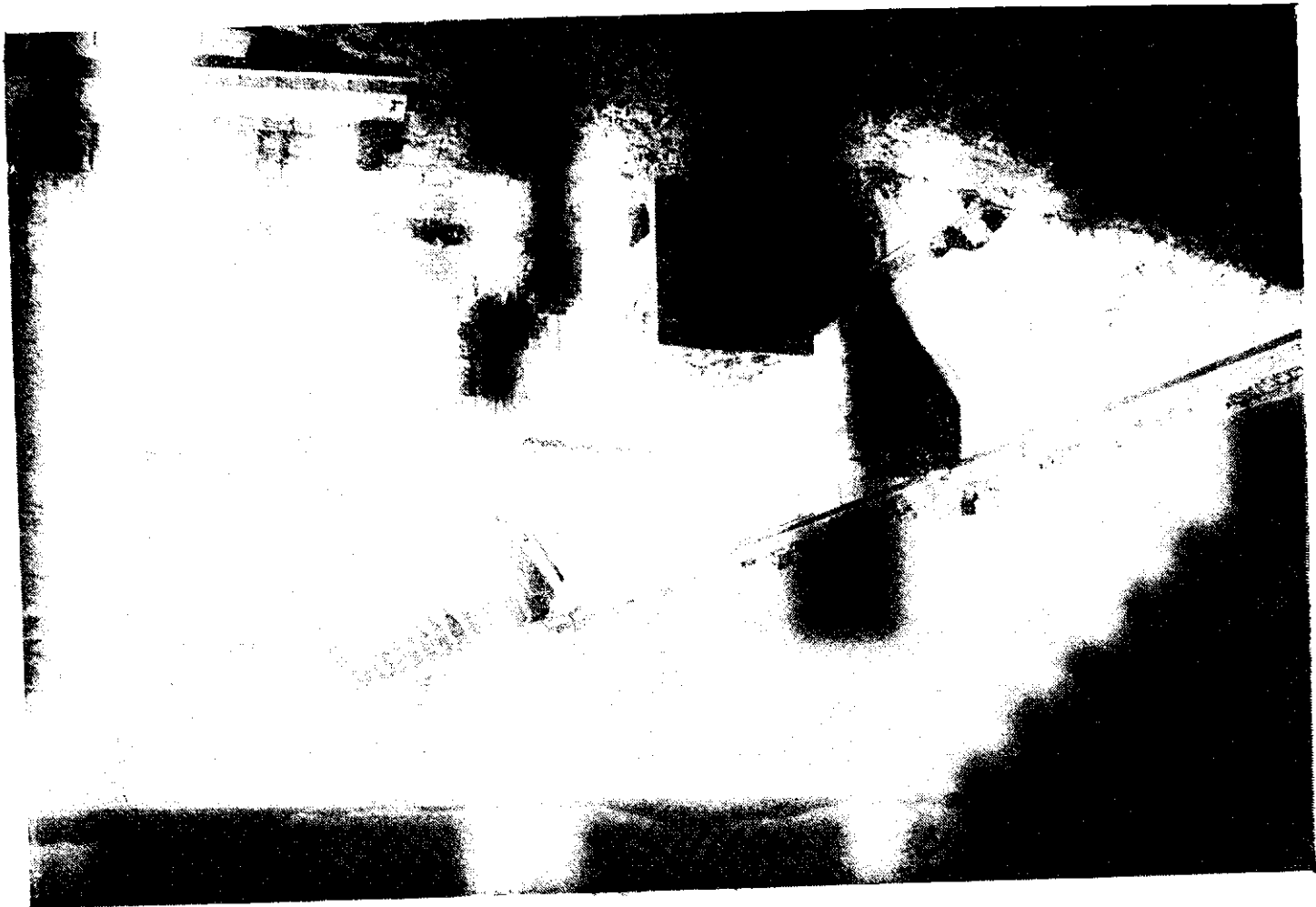
The Hirakud Dam Project is a Project of the State Government of Orissa but the Government of India undertook the responsibility of executing it and the capital needed for its construction has been treated as a loan to the State Government. It was not possible for the State with its limited financial resources and technical personnel to undertake the execution of a project of such gigantic magnitude, costing about Rs. 100 crores.

As agreed between the State and Central Governments the Project Organisation is divided into two branches :

- (i) The Construction Organisation ; and
- (ii) The Land and Development Organisation.

The Constructional Organisation deals with matters concerning the actual construction of the Dam, Power Houses, Canals, Transmission Systems and all works connected therewith, except land acquisition and other matters connected with land.

The Land and Development Organisation was placed under the control of the Government of Orissa. It deals with matters relating to land acquisition, reclamation and resettlement, and development concerning the Hirakud Project. The Member, Board of Revenue, Orissa, at Samba:-

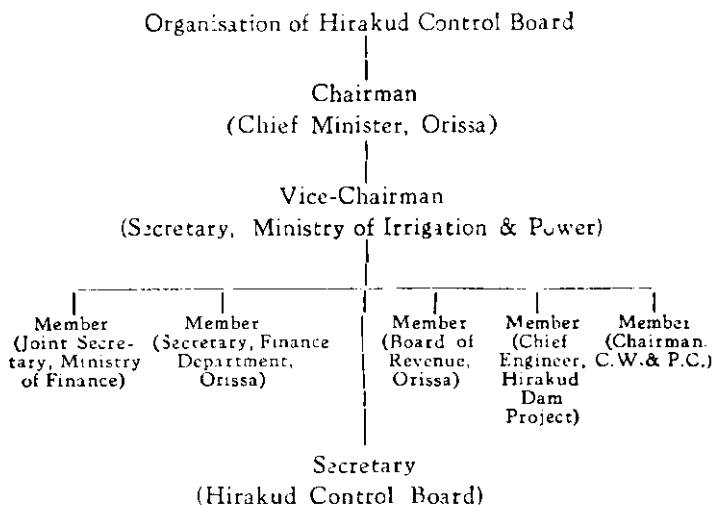


Rightdam,—Power House and Tail Race

pur, was placed in direct charge of the organisation assisted by an officer of the rank of Deputy Commissioner. A separate department - River Valley Development Department was created in order to look after all matters concerning the Hirakud Project with which the State Governments are concerned.

The Construction organisation was originally placed under the C. W. I. N. C. (now designated as C. W. & P. C.) with a Chief Engineer at its head. A Contract Board set-up under the Chairmanship of the Chief Minister of Orissa, dealt with matters of major policy concerning the project. However, with the experience gained, it was found necessary to delegate larger powers to the Hirakud Organisation so that it could take quick decisions and expedite action and thus avoid delay which was inevitable if every matter was referred to the Central Government for their approval. Therefore, in March, 1952, this arrangement was revised and the Hirakud Control Board, under the Chairmanship of the Chief Minister of Orissa, was constituted with three representatives from the Centre and two from the State. This Board has been placed in overall charge of the project including its technical and financial aspects, under the general supervision of the Government of India. In 1953, the C. W. & P. C. was relieved of its responsibility in regard to the construction and the Commission now functions in an advisory capacity in respect of this project. The Chief Engineer of the project is directly responsible to the Control Board and the Irrigation & Power Ministry of the Government of India. The Hirakud Control Board is assisted by a Development Board under the Chairmanship of the Member, Board of Revenue, Orissa, at Sambalpur. The Development Board is responsible for the development aspect of the project *viz.*, irrigation, industries, power-distribution, etc. The resolutions and decisions of the Control Board are recommendatory

in nature, Government sanctions, where necessary, being issued by the Government of India or Government of Orissa as the case may require. The organisation of the Control Board is shown in the following chart.



The Chief Engineer is in charge of the Project Organisation and is directly responsible to the Government of India, through the Hirakud Control Board, for both the efficient administration and general professional control of public works on the project. He has been delegated large powers through the Hirakud Control Board to contract for works, supplies and services on behalf of the Government of India.

The Project is divided into five circles, (i) Hirakud Dam Circle, (ii) Mahanadi Canal Circle, (iii) Dykes, Design and Investigation Circle and (iv) two Electrical Circles, each of which is under the administrative control of a Superintending Engineer, who is responsible to the Chief Engineer for

administration and general control of public works under his charge. The Superintending Engineers have been delegated decision-making powers by the Chief Engineer.

Each Circle is further divided into a number of divisions and sub-divisions under the charge of Executive Engineers and Sub-Divisional Officers who are responsible for management and execution of work in their jurisdiction.

The Superintending Engineer, Mahanadi Canal Circle has also under him a Designs Office incharge of an Executive Engineer to draw up the Designs of the canals in the Project. The C. W. & P. C. is incharge of the design of the Dam and the power house.

In the revised set-up, a Central Purchase Section has been constituted under the control of the Chief Engineer for all the purchases to be made. A comprehensive medical organisation with two main hospitals at Burla and Hirakud in charge of a Chief Medical Officer is also part of the Project organisation.

On the financial side, there is a Financial Adviser-cum-Chief Accounts Officer as also a Resident Audit Officer.

The Financial Adviser-cum-Chief Accounts Officer is under the direct control of the Finance Ministry of the Government of India. He is the principal disbursing officer of the Project, maintains the accounts of the Project, gives advice to the Chief Engineer in all financial matters and keeps himself in close touch with the pace of expenditure on the project, correlating the progress of expenditure with the progress of work.

The Resident Audit Officer is responsible for performance of the statutory function of audit on behalf of the Comptroller and Auditor General of India through the Accountant General, Orissa.

Under the revised administrative set-up, the entire organisation and working is centred round the Chief Engineer under the overall charge of the Hirakud Control Board. The Chief Engineer exercises large powers but also has large responsibilities. With the powers delegated to him, he can act with greater freedom and take quick administrative decisions. This has enabled the execution of the project works to with speed and efficiency.

The other important organisational factors which have contributed to the accelerated pace of the work are the establishment of the Designs Office in the Mahanadi Canal Circle, the Central Organisation for purchases under the direct charge of the Chief Engineer, greater attention to maintenance of equipment and better personnel management of the departmental labour.

CHAPTER XII

RESEARCH ENSURES STRONGER STRUCTURE AND ECONOMY IN COST

The Project has a well-equipped research laboratory responsible for :—

- (i) Daily field check of materials used in the actual construction of the dam ;
- (ii) The laboratory work on soils, concrete, stone and mortars ; and
- (iii) Miscellaneous investigations such as :
 - (a) soil surveys in the agricultural areas,
 - (b) silt surveys and analysis, and
 - (c) experiments on materials for cheap housing construction, e.g., cheap and durable bricks and fire proofing of the cheap and normal roofing material in rural areas.

Due to increasing application of advancing scientific knowledge in dam construction, laboratory research and field testing of materials used for construction, have acquired a new significance. Instead of any soil being used in the earthen dam structure, soils are subjected to elaborate laboratory tests in respect of permeability, compaction and stability characteristics which are determined largely by the size, distribution and mineral composition of soil particles. Therefore, both physical and chemical tests have become essential for determining the suitability of a soil sample for use in the

various zones of dams. Besides the variety of soil, moisture content of the soil greatly affects the degree of compaction. Hence continuous testing of the soil samples at the site of actual construction for their moisture content and degree of compaction constitutes an essential feature of dam making now-a-days. Similarly, designing, placing, compacting and curing of concrete mix to get a strong and durable structure required a proper understanding of the nature of aggregates used and the size and shape of structures and pressure which they have to bear. The use of masonry in massive dam structures needs constant checking of quality of stones, sand and strength characteristics of mortar used. It is, therefore, clear that a research laboratory plays a vital role in the course of investigational and constructional stages of major river valley projects.

The Research Station has made a significant contribution in the construction of the earth, concrete and masonry structures of the dam. Testing of the material used to ensure a high degree of consolidation, imperviousness and durability to the dam structure and thereby a longer life to it has been an important activity of the Station. Throughout the period the construction work continued, the Research Station had been busy in surveying appropriate soil material and in classifying it into impervious, semi-pervious and pervious varieties according to the degree of water-tightness on compaction. It had to establish field laboratories at the actual sites of operations for various tests. In borrow areas, wherefrom the soil material was obtained for dam construction, the field laboratories tested the soils for their suitability and guided the movement of the soil to different zones of the dam. At the dam site, the field laboratories conducted constant tests of moisture content and compactness achieved of the soil layers in the earthen dam structures.

The bearing pressure of different soil strata had also to be found in connection with the designing of foundations of appurtenant works such as aqueducts, bridges, etc., on the canals.

Similarly, in the case of concrete and masonry structure, research in the main laboratory and tests in the field laboratories were conducted to determine the suitability of the various concrete mixes with a view to affording maximum strength and impermeability to the structure and also to economise in cost.

The consignments of cement were checked and adversely affected lots due to long storage or exposure were not permitted to be used in major constructional works. The coarse and fine aggregate materials were constantly checked for quality and grading. Concrete samples at placing were drawn and tested by the field staff. Sets of tests cylinder were cast in the field and tested for strength at different ages.

A correct appraisal of the probable rate of silting, is of very great importance to a storage dam. Therefore, a day-to-day assessment of silt load has constituted an important activity of the Research laboratory since 1947. The silt samples are collected from a number of discharge sites on the Mahanadi. The data provide useful information on the disposition of sedimentation in the Hirakud Dam reservoir.

Another important task, of the Research Station has been the survey of agro-irrigational possibilities in the areas to be brought under irrigation. For this, intensive soil surveys were conducted both in the area coming under the command of the canals and also in the area reclaimed for settling the displaced population from the submerged area.

Useful work has been done in the direction of testing of suitable material for low cost and temporary housing required under the Project and in evolving cheap and effective means to render thatch roofs of the village houses resistant to fire hazard.

CHAPTER XIII

HOUSING AND WELFARE

The execution of the Project did not merely entail handling of stone, cement, concrete and earth but also involved looking after the welfare of a large working force consisting of men and women brought together from distant places, speaking different languages. In the Project, besides a large contingent of technical and office workers, the number of departmentally employed skilled and unskilled labour was nearly 7,000. The labourers employed by the contractors on various works numbered about 20,000.

As the dam was located in an out of the way and isolated place in the scarcely settled region of Orissa, the housing of staff and workers was the first major problem which the project administration faced. The work of the project was spread over a wide area and extended on both sides of the Mahanadi. Colonies and extension camps had to be built at a number of places for convenience in work. Among the settlements formed, two colonies on the two banks of the river are the major ones. The Hirakud Colony Left on the left bank of the river was the first to be built. It is about 9 miles away from the nearest town of Sambalpur. Its population has gone up to more than 10,000. The Hirakud Colony Right is situated on the right side of the river about 3 miles to the east of the main dam in the village Burla. The Head Office of the Project is located in this colony. This colony has been provided with all the necessary amenities, like post office

High School, hospital, market, a co-operative community centre and an open-air theatre, two, fine double-storeyed rest houses and one six-room and two twelve-room hostels have been built for official guests, visitors and tourists.

Colonies have been constructed at Chiplima which is the site of the subsidiary dam power house, at Bargarh for the staff engaged on the construction of main canal. Small colonies have also been built along the canals and transmission lines and at the Power sub-stations. The colonies are self-contained townships and meet all the needs of the people. They stand in striking contrast to the neighbouring area which is so little developed.

An important consideration in building accommodation for workers was the temporary nature of requirements as, on the completion of the Project, the working force would dwindle considerably in strength. But the houses had to be built to provide at least a reasonable degree of comfort to the worker after his day's toil. So in designing the houses, both the cost of construction and the comfort of the occupants, received due consideration.

In all, 10 types of houses of permanent, semi-permanent and temporary nature have been built for the various categories of staff and workers. Every care was taken to economise in cost by judicious variation in the kind and quantity of material used in foundation, superstructure, roofing, plastering, flooring, doors, windows, etc. Over 2,000 huts were constructed for the labourers.

Filtered water for domestic purposes is supplied to both the colonies from the Mahanadi. The labourers' colony on the right side has been provided with a separate system of water supply. The Left Colony is fitted with flush system latrines.

In the labour colonies, there is provision for ample protected drinking water supply, first aid posts, dispensaries, hospitals, doctors to look after their welfare, electric lighting, sanitation and recreation facilities. There is a Labour Officer to look after the interests of the workers, get their grievances redressed and deal with matters relating to wages and employment. The Chief Medical Officer attends to both preventive and curative side of medical relief of the staff and labour. He is also in charge of sanitation and anti-malaria activities on the project.

It is, thus, clear that the personal needs of the staff and labour are well looked after. No efforts have been spared to provide all reasonable amenities to them. It is this attention to personnel management and the well-being of the staff and labour that has contributed to happy relations between the labour force and the Project Administration and to the acceleration and efficient execution of works on the Project.

CHAPTER XIV

THE BALANCE SHEET

The many benefits ensuing from a multi-purpose river valley project such as stabilised economic life leading to moral and social improvements and rise in the standard of living alleviation of human misery due to the control of floods, better sanitation, medical and education facilities due to larger expenditure on welfare activities etc., are not convertible into money. Nonetheless, it has become a fashion to work out the money return on the capital invested in the Projects. Before a project can be accepted, both the Government and people have to be convinced that it will yield economic returns.

The financial forecasts for Hirakud have been prepared on the usual pattern. Revenue from water rates, betterment levy, sale of power has been taken into account. The return from Irrigation and Power works out to 1'84% for Stage I only. However, taking into consideration the Delta Irrigation Scheme and Subsidiary Power House Scheme which has been subsequently sanctioned, the financial return from the project is considerably enhanced. The overall benefits of the whole Scheme estimated to cost Rs. 100'02 crores are :

Irrigation	25,39,094 acres
Power	2,32,500 kW installed capacity

The scheme is fully remunerative and no part of the cost is being debited to flood control.

The three sources of revenue on the Project are:--

- (1) Water rate
- (2) Betterment levy
- (3) Sale proceeds of power

The Hirakud Control Board during 1952 set up a Committee with the Commissioner, Northern Division, as Chairman to go into the question of water rates and betterment levy. This committee studied in detail the scope of the project, the existing sources of irrigation and crops cultivated, actual expenditure incurred by the *rayats*, probable amount required to be spent for various types of soil and the net benefit that will accrue due to irrigation. Based on these data, reasonable water rates for various types of soil and betterment levy have been arrived at. The Government of Orissa have since then passed legislation for the imposition of betterment fee. They propose to collect half the increase in capital value after allowing for cost of improvement. The increase in capital value is assessed as ten times the value of additional produce. This fee ranges from Rs. 75/- to Rs. 100/- per acre. As regards water rates no final decision has been taken yet by the State Government. The water rates vary from Rs. 7/- to Rs. 16/- depending on the nature of crop-food or money crops.

As regards power, the Orissa Tariff Committee have drawn up a schedule for the charges to be levied for different types of loads and consumers. Based on this and the anticipated rate of power generation, the project engineers have worked out in detail the estimated revenue and operation costs etc.

Assuming that the anticipations of the engineers would materialise the continued Hirakud Project on completion is expected to yield a return of 4.61% in the 10th year of

operation. This is on the assumption that *Kharif* irrigation will develop in full within 5 years, and *Rabi* in ten years. Power will be fully consumed within this period. The additional agricultural production on completion of Hirakud Dam is estimated at 4 lakh tons, valued at 12 crores. The benefits in terms of money by use of electricity is inestimable. It caters to the manufacture of iron and steel, aluminium, ferro-alloys, textile cement and many other large-scale satellite industries.

Hirakud is the forerunner of many industrial ventures in Orissa. The experience gained there is invaluable. It will enable Orissa to build other projects and usher in a new era of plenty and prosperity.