

MODELS

*save
Millions*

**HODGHLY
PORT MODEL.**
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SALKHIA

HODGHLY
RIVER
MODEL

CENTRAL WATER AND POWER RESEARCH STATION, POONA

1953

Models Save Millions
Central Water and Power Research Station

P O O N A



CENTRAL WATER AND POWER COMMISSION
MINISTRY OF IRRIGATION & POWER

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CHAPTER I

TOWARDS KHADAKVASLA

A SLEEPY little village some miles out of Poona, Khadakvasla, has come into fame because of the fortuitous circumstances that one of the best engineering research institutions in the East is stationed beside it. Poona itself is best approached from the north. Starting from Bombay, a powerful electric train whisks you down and, literally, through the Western Ghats (hills) hardly in three hours. During this cleanest railway journey in India (as the train is driven by a double-faced electric locomotive instead of a smoky steam engine) the train shoots through 27 rocky tunnels in 120 miles and negotiates inclines as steep as 1 in 37.

This engineering feat is not the only marvel: the journey is one long winding panorama of Nature to be lost in quiet contemplation. At a wayside station where the train stops, one can 'hear' the pervading stillness of the valley. (You notice there is no hiss of the steam engine to break the silence). As you stream along, on both sides rise the sky-kissing hills; or, in places, on one side is a massive, towering granite wall and on the other an awful chasm.

If you happen to be travelling after a liberal monsoon, glorious pictures of green-mantled hills bathed in golden

sunshine burst upon you every time you emerge from the pitch-dark burrows—the tunnels. And shimmering streams through verdant valleys, like silver ribbons on a sheet of green silk, wind their way in the misty distance. Occasionally giant water pipes, in twos and threes, race each other down the forest slopes to feed the power stations; or skeletons in steel—the electric transmission towers—flash past, and altogether make short work of the journey and bring the visitor to his destination in a humbled but none the less pleasant frame of mind.

Poona is not only a great city of today: it is an old city of traditions, chock-full of history. It is so unlike Bombay, with all its rush and run, its multi-storied flats very much like beehives, and its cold way of life—each for himself. There is an intellectual and cultured leisureliness about Poona that is appealing, a neighbourliness that helps one view with indulgence the failings of the world. Wedged in between the Mula and the Mutha rivers, the salubrious climate of the place drops a mantle of peace and equanimity on the stranger.

Shivaji's birth and exploits round *Pune*—as it used to be called—surround the city with an aura that has inspired



A Double-Faced Electric Locomotive

The use of electric locomotives for trains between Poona and Bombay makes it one of the most delightful journeys in India.

many a great patriot. Tilak, Gokhale, Ranade, and Chip- lonkar who braved the British rule, each in his own way, hailed from Poona. Although it lost its political importance after the Maratha empire faded away, Poona may still claim to be the cultural capital of the State.

Some of the earliest institutions in the country for intellectual advancement and national service were founded here and are still thriving. The Deccan Education Society, the Indian Women's University, the Oriental Bhandarkar Institute, the Servants of India Society, the century-old College of Engineering are some of the proud centres of learning that dot the city. The latest in the line are the

National Chemical Laboratory, the Military College of Engineering (Kirkee), the National Defence Academy, and the newly founded University of Poona. It is this eminent company that the Hydraulic Engineering Research Station has pioneered by its modest entrance 35 years ago.

The main office and certain sections of the Research Station are situated in Poona itself. It is the model-research laboratory, which calls for a constant supply of large volumes of running water, that is conveniently located at the foot of Lake Fife at Khadakvasla. And the experiments are so fascinating that it attracts even school children to the Station.

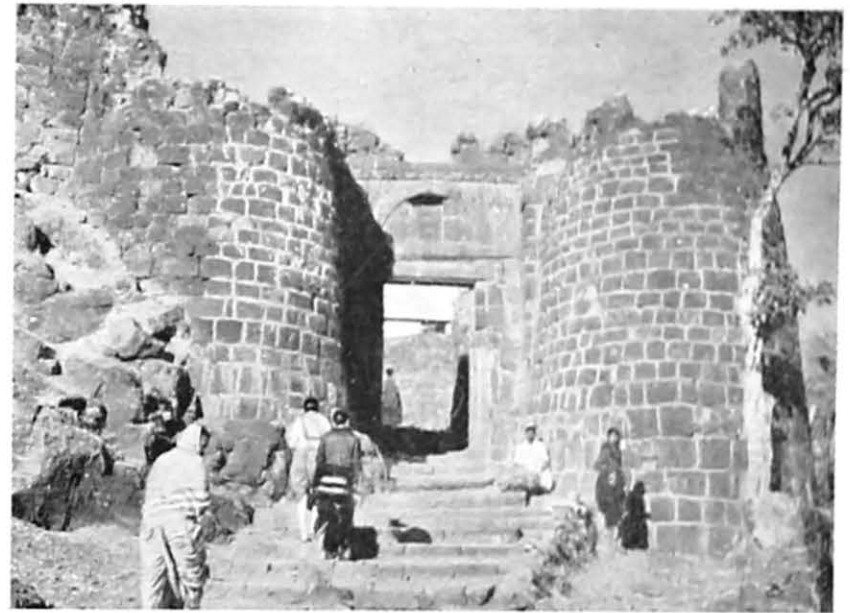
Hardly eleven miles of motoring, north-west of Poona, brings the visitor to the open-air hydraulic research laboratory. And this short run is not without its attractions either. The road, for half the distance in concrete, snakes its way through green fields of jowar, sugarcane and rice, fed by a canal which runs either with you or crosses your path to Khadakvasla and the Lake Fife. The canal is in fact on its 80-mile journey from Lake Fife, for servicing vast irrigation fields and the city of Poona. On the way to Khadakvasla can be seen a bend of the Mutha, through wooded banks and banana plantations, gently making its way after filling the Lake at Khadakvasla.

Another striking feature is the tall and tapering Parvathy temple perched, as one would imagine gods to be, high up on the sunlit peak of a hill which is approached by gracefully winding steps of black granite. An ancient Peshwa palace stands close by; and what was once a tank at the foot of the Parvathy hill is being turned into a playground and a zoo-garden, the Peshwa Park.



**Bust of Tanaji Malusare in
Sinhagad Fort**

Tanaji Malusare was one of the noblest commanders and the right hand man of Chhatrapati Shivaji who assisted the great leader in establishing the Maharatta Empire. Tanaji laid down his life in the battle for the capture of the Sinhagad Fort. The combat between the Generals, Udaibhan, the Rajput convert in the pay of the Moghuls and Tanaji; the tragic death of the heroes; the triumph of the Maharattas under Tanaji's uncle form a stirring episode in the history of the Maharatta Empire. On hearing the death of Tanaji, Shivaji is reported to have said "The lion is lost though the Fort is won". The bust of Tanaji Malusare today stands at the spot where he breathed his last in the struggle against Muslim overlordship.



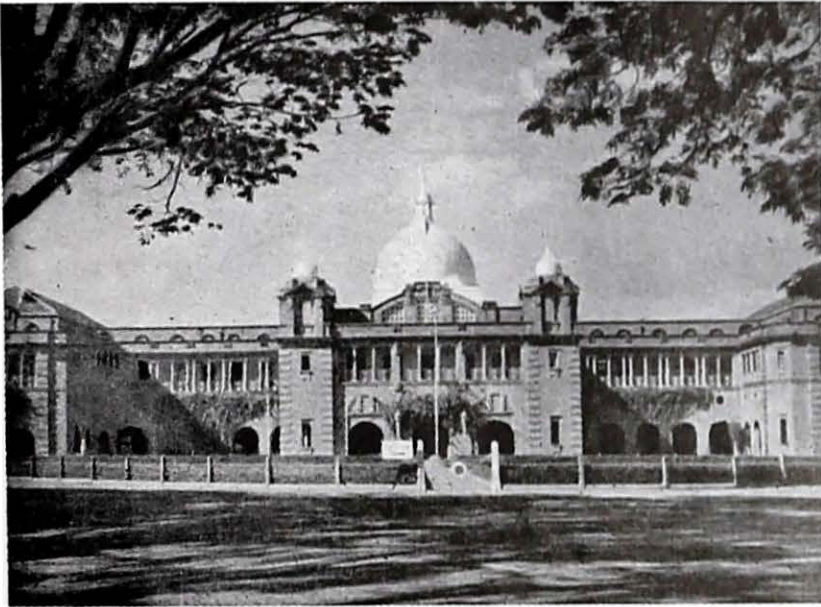
Portal of the Sinhagad Fort

The Panoramic View from Sinhagad Fort



Samadhi of Tanaji Malusare





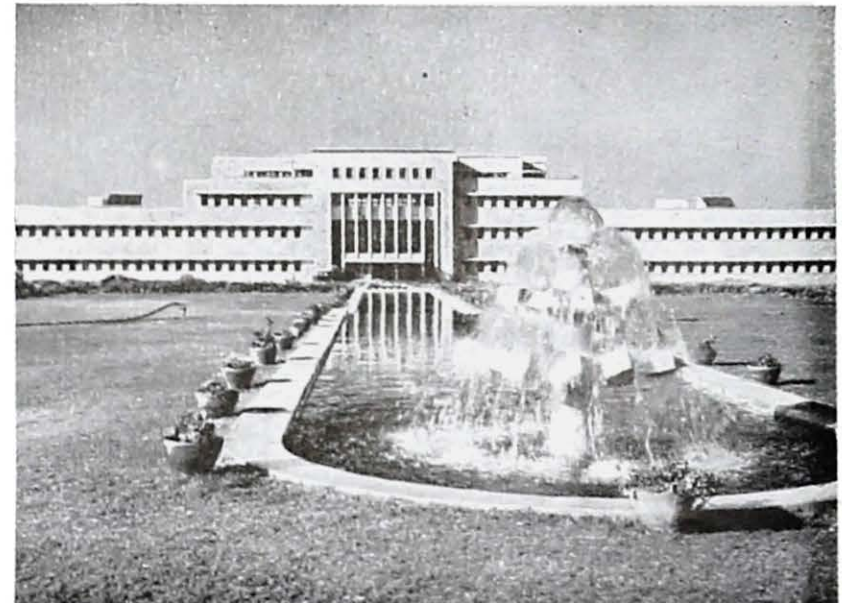
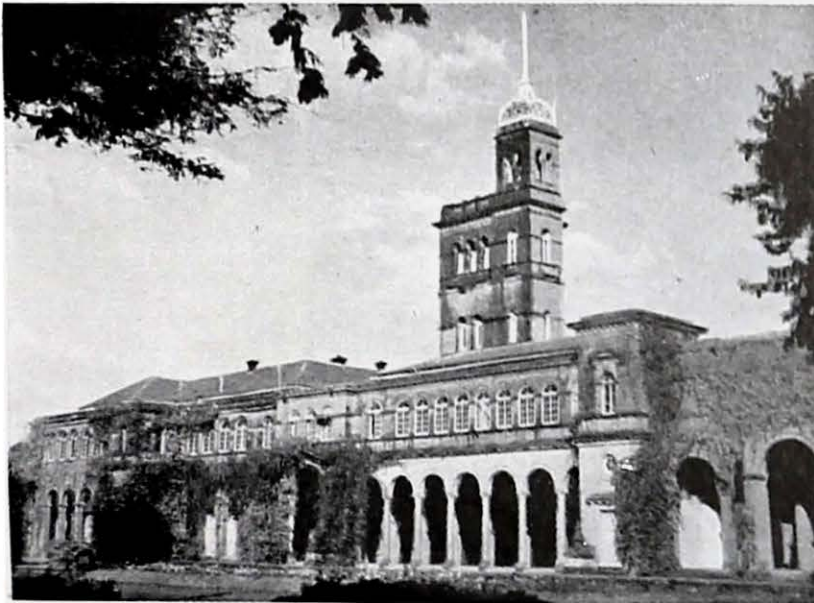
The Agricultural College, Poona

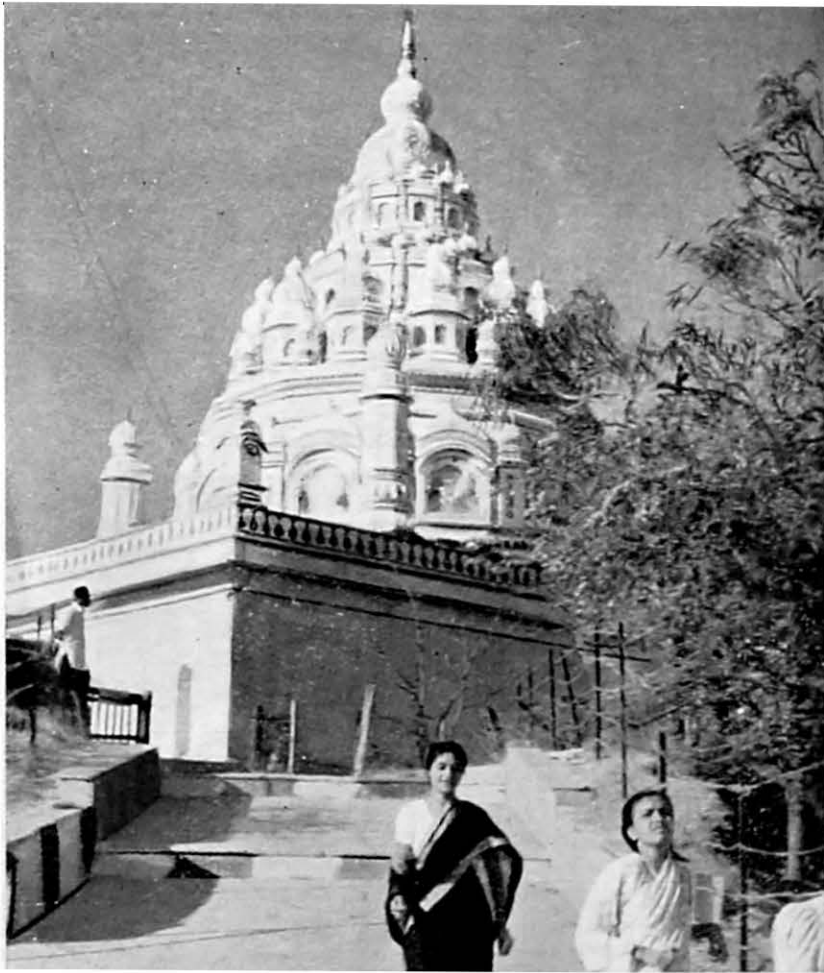
The University of Poona



The Summer Seat of the Bombay Government

The National Chemical Laboratory, Poona



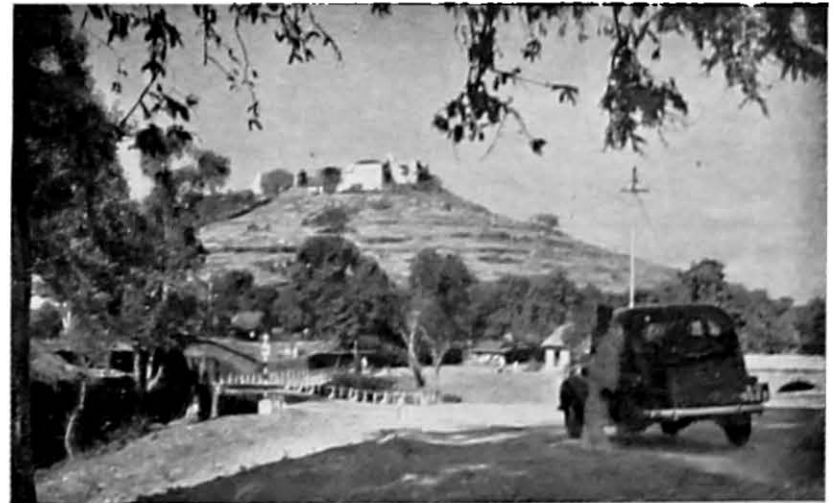


A Close-up of the Parvathy Temple

At Khadakvasla the Lake Fife itself is an unglamorised beauty spot. The flanking green slopes are mirrored in the placid sheet of deep water which offers an ideal playground for sailing, swimming and other water sports. On the hill at the farther end of the lake, the National Defence Academy is fast taking shape. From the lake itself two canals radiate from each end. The Hydraulic Research Laboratory is located at the mouth of the Mutha right bank canal, and covers an area of 150 acres. Not only a number of new models are being laid to solve the various problems submitted by the State and Central Governments, but workshops, administration blocks, and tanks and sheds for a navigation research project have been put into Commission.

The Picturesque Parvathy Temple perched on a Hill

The temple is a pleasant landmark on the way to Khadakvasla. At the foot of the hill a zoo and a playground are taking shape.



CHAPTER II

PROBLEMS AND SOLUTIONS

It was a critical time during the last world war in 1944. The conflagration had spread to the East. Japan had overrun Burma and was at India's door at Imphal. It was a last ditch battle for the Allies who were fighting for life. All supplies—food, fuel, ammunition, clothing—had to be rushed to Calcutta and thence to the front. As ill luck would have it all other rail links had been cut off during the Damodar floods. And the fate of the Allied army at the Eastern front hung literally by a line—the vital railway that connected Calcutta with the rest of the country. A natural calamity threatened this life line too.

The railway runs across the Rupnarain river, about 35 miles west of Calcutta. From 1938 onwards there was insidious erosion of the left bank which brought the river dangerously close to the rail track. In 1943 it flowed hardly 1,500 feet away and threatened to cut off the only link left to feed Calcutta and the war front.

Why Experiment ?

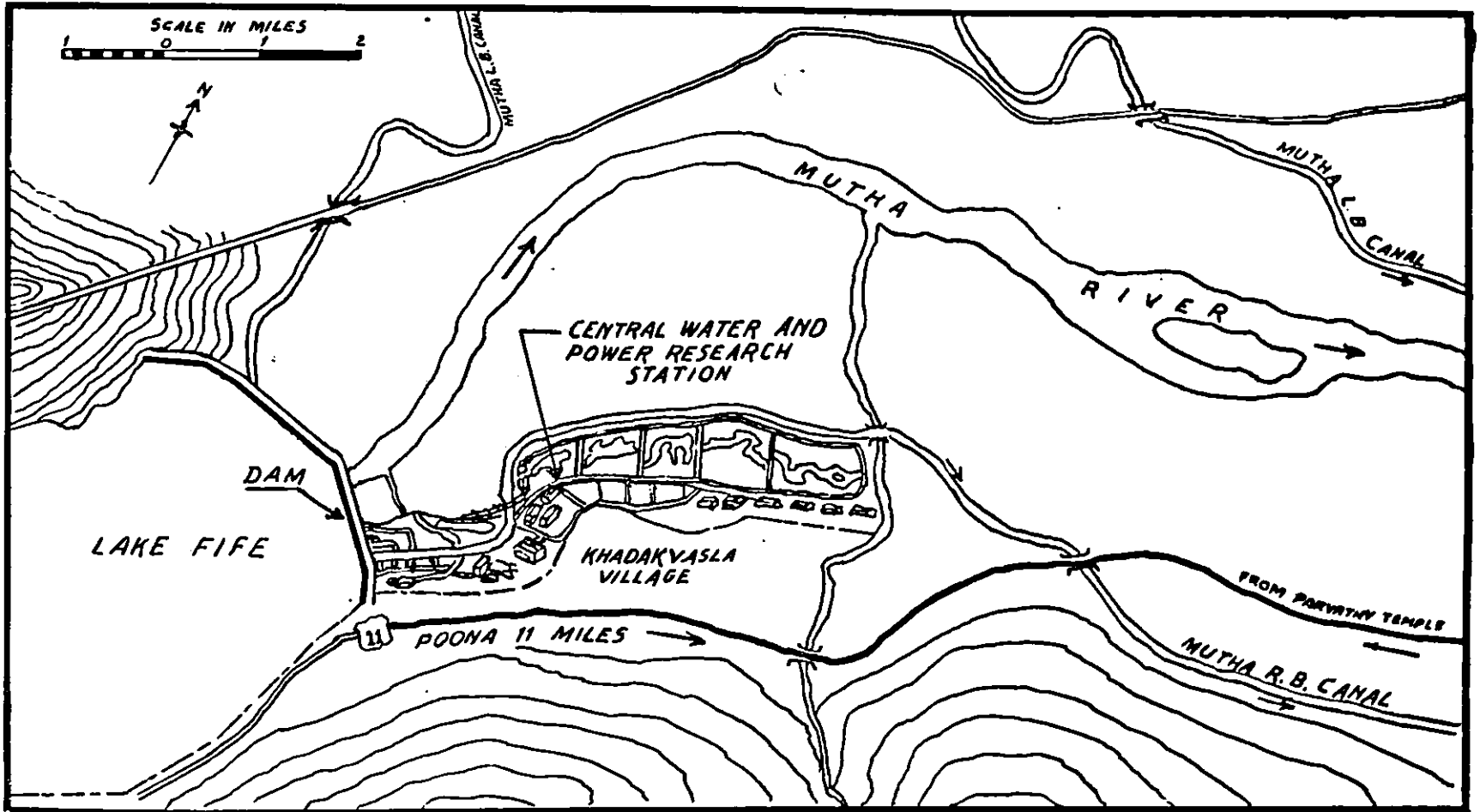
Well, as is usual in such cases, there were a number of suggestions. The easiest was to build a new bridge at a safe distance. But it would cost about two and a half crores

of rupees and, more precious, take an unconscionable time.

The railway engineers suggested a series of short barrier

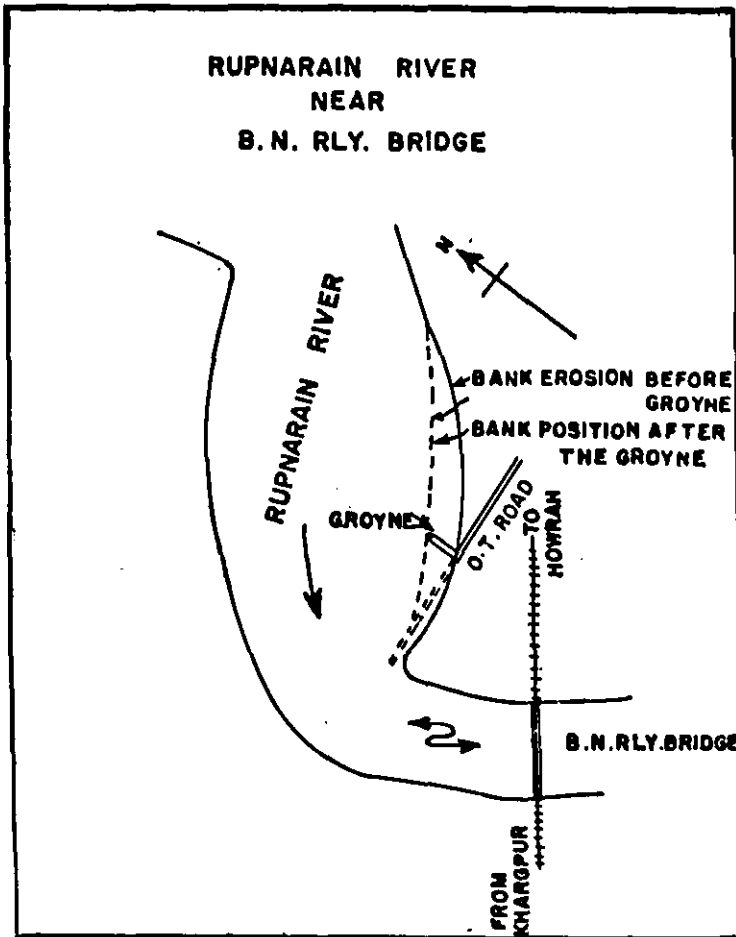
Lake Fife Formed by the Khadakvasla Dam





Location of the Central Water and Power Research Station

The Central Water and Power Research Station is situated at the foot of the dam across the Mutha River, 11 miles from Poona, close to the Khadakvasla village. The office, the workshop and the models extend over 150 acres on either side of the Mutha Right Bank Canal. Established in 1916 on a modest scale, the Research Station is now the largest in the East whose services are placed at the disposal not only of all the States in the Union but of all friendly neighbouring countries.



A major achievement of the Central Water and Power Research Station at Poona is its work for preventing the Rupnarain river from outflanking the B. N. Railway Bridge at a critical time during the period of World War II. How the threat to the bridge was averted is described alongside.

walls built out of the railway embankment at right angles to the line of flow. These groynes they thought would keep the river at bay. This too would be fairly expensive and of dubious value, for some engineers were of the opinion that the remedy would in fact aggravate the disease.

Another suggestion was to build a long curved bund some distance upstream of the bridge; and a fourth proposal was to erect an oblique wall protecting the left bank that was being eroded. Thus the solution was anybody's guess—but a costly one it would be, if it did not work out right.

Value of Model Experimentation

At this stage the Research Station at Poona stepped in. Scale models were made of all plausible solutions. Some of them worked, some did not. Some were more expensive, some less. Of these the most economical remedy consistent with safety was adopted. And all this was done within a few months.

In the case of the Rupnarain, the successful solution was a 1,100-foot wall angled at 60 degrees to the left bank running upstream above the bridge. The groyne not only stilled the water flow that threatened the railway embankment and stopped erosion, but silt began to collect, building up new land alongside the railway track—just as it was anticipated in the model experiment. In 1950, six years after the construction of the spur, the river was flowing about 5,000 feet away from the track, the land in between having shoaled up to a depth of 12-18 feet with silt.

The Rupnarain Model is but one instance of the utility, economy and ultimate efficiency of design of engineering structures proved by trial-and-error experiments on scale

models. Among numerous others are the Hardinge Bridge and the Garhmukteswar Bridge across the Ganga which were brought back into effective service through model experiments. Looking over the results of the engineering research station at Poona achieved through decades, one cannot but appreciate the wisdom of putting to a stringent test new theories, designs and suggested solutions to the problems in a field of endeavour which is as yet largely empirical.

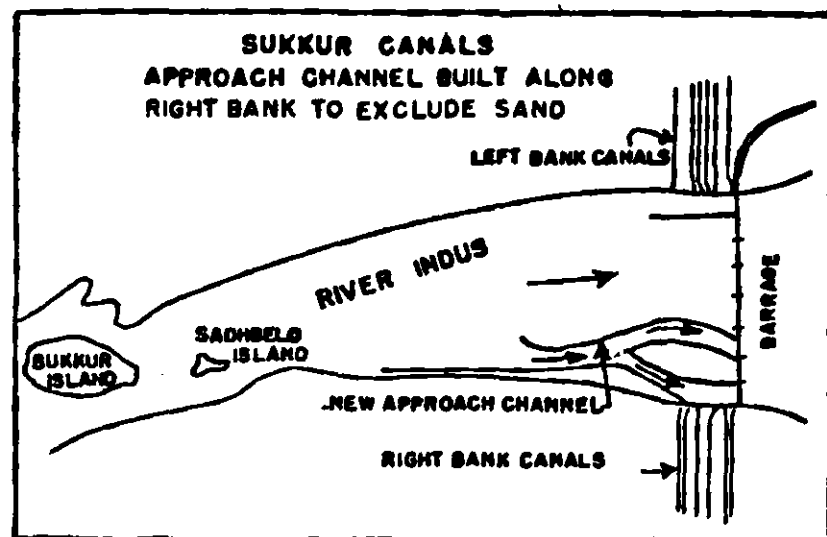
As in other professional fields, here also exist different opinions on the reliability of conclusions based on the results of hydraulic models. While some engineers swear by model experiments for hydraulic structures, there are others who declare that it is dangerous to place much faith in them. And as usual the truth lies somewhere between the two.

But the cost of scepticism can be heavy sometimes, as it happened with the right bank canals of the Sukkur Barrage in Sind. Years before the Barrage Scheme was completed, experiments at the Poona Research Station showed that the canals, as designed by the field engineers, would soon be choked with sand, reducing their capacity. To obviate this defect certain devices were also suggested. The Sind authorities were however doubtful of the recommendations and consequently ignored them.

Five years after the Barrage started functioning the Rice and North Western Canals on the right bank silted up more than five feet. Several lakhs of rupees had to be spent on sand clearance. Methods had to be devised, again

through model experiments, for excluding sand from the canals. The new approach channel built on the recommendation of the station effectively improved the flow in the canals.

Model experimentation is thus a composite science calling for a knowledge of pure sciences like mathematics and physics, over and above the prescribed engineering curriculum, plus a bit of intuition—the more the better. Up to a point, however, there is a common procedure for model experimentation which is easily followed.



Designing of the approach channel to the Sukkur Canals (now in Pakistan) clearly establish the utility of model experimentation in the design of irrigation structures.

CHAPTER III

THE MODEL TECHNIQUE

Tricks of Model Laying

THE making of a river or harbour or dam model for solving a major problem is not all fun. Theoretically, of course, if you can reproduce in the model every detail of the original in exact proportion, every condition and problem will also be reproduced. But there are obvious limitations within which the experimenter has to work, and handicaps to which he has to resign himself. If for instance a 300-mile river is scaled down to 300 feet, its depth, on a proportionate scale, would be less than an inch—too minute to work in the vertical features of the channel and the river bed in the model. Nor is it always necessary, fortunately, to reduce all the dimensions to the same scale. A convenient scale is therefore chosen for the depth, taking care to see that the vertical exaggeration does not affect the reproducibility of the particular problem under study.

Selection of Factors

Considerable experience and a rare degree of imagination are called for in assessing the relative importance of the numerous factors involved in a problem. For, as

explained earlier, it is impossible to reproduce all conditions existing in the original with exactitude.

As an example, consider the scour at the foot of bridge piers. In this action the velocity and direction of water-flow, the shape and depth of pier foundations are the chief factors. Obviously the height of the pier, or the number of piers under the bridge have little to do with the damage to the foot of the pier. Therefore the results obtained in



Scour round Bridge Pier

a model with a single pier (as in the picture below) should answer the problem in general.

The experimenter should therefore know beforehand the principal conditions that have to be reproduced and the degree of faithfulness demanded of each. And the more complicated the problem, the greater the need for careful choice of factors that really count. Only a long and intelligent service coupled with a hunch for spotting the right causes and solutions will help in taking decisions and avoid repeated trials in perfecting the model and spotting the remedy.

Models and Models

For the design of sluices, spillways, and gates of dams meant to let out surplus water, in which gravity is the governing factor, the models are laid to a geometrically-similar scale. They yield results which fit the original like a glove.

There are others which require corrections and allowances before the results can be applied. These are generally the models of alluvial rivers, tidal rivers, tidal estuaries, etc.

But the most complicated of all are the problems relating to tidal rivers, where the flow of water at the mouth and in the delta alternates up and down the channel with clock-like regularity. Here the solutions are most ticklish, as they should work not only for the normal flow of the river, but for conditions when the flood tide of salt water from the sea periodically rushes in in the opposite direction.

Despite all the complications and difficulties, model experimentation is not a haphazard business. Continuous and intensive research all over the world in this new field has helped in defining its scope and limitations, and has resulted in the development of a specialised and methodical

science. It has its laws, its techniques, methods and standard procedures.

Models in which only gravity plays its part are the simplest, for its value is the same both for model and for prototype. Those in which friction comes in are governed by well-defined factors of proportion. And so on, with surface tension, viscosity, inertia, etc., creeping in, until the most complex problems end with an appeal to the experience and the sixth sense of the experimenter. The results in such cases often have only a qualitative applicability.

Proving the Model

Once the scale is chosen and the factors and features to be reproduced in the model are decided upon, the model is laid on a concrete surface, and a suitable bed material like sand is spread along the channel. Now the model is ready for testing.

Water is run through the model at a regulated speed. Wherever the anticipated conditions are not reproduced as exactly as desired—silting up in certain places, erosion or scouring at others, shoal formation at certain exact points, etc.,—structural modifications are introduced until the model behaves as in the original in respect of the selected factors.

Now the model has been proved, and is ready for trying out measures for the solution of the problem. In other words, the premise is that if a model reproduces the original problem reasonably faithfully, the remedial measure worked out in the model will be reasonably successful in the prototype. And this has been found to be generally true of the results obtained in actual practice.

CHAPTER IV

HISTORY OF THE STATION

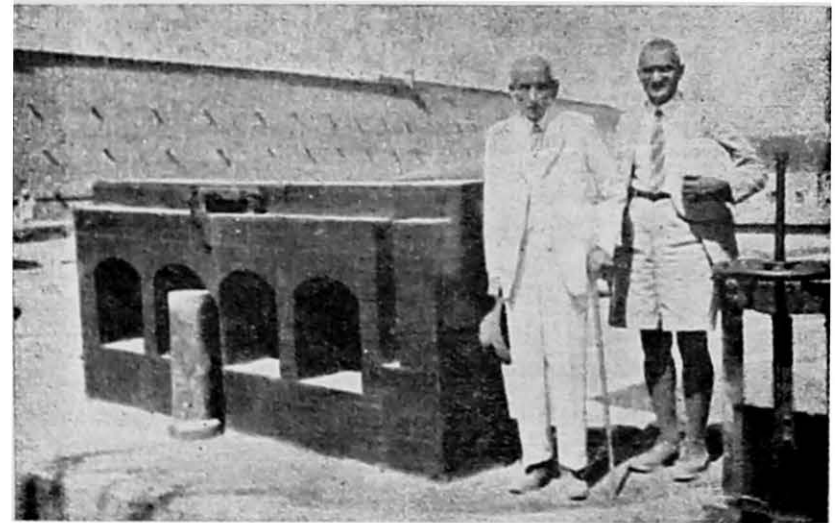
As the visitor enters the open-air model-laboratory at Khadakvasla, he is first taken to a miniature dam with sluices, whose gates are connected by a simple system of pulleys to floats in wells. As the water level in the reservoir rises above a fixed level, the wells get filled pushing up the floats which, in turn move the gates, allowing the surplus water to flow downstream. As the level in the reservoir goes down and the wells empty, the floats and the gates operate in reverse, cutting off the outflow from the reservoir. This automatic device is working effectively to this day in the Khadakvasla dam. You are proudly told that it was designed by the famous Indian engineer Sir M. Visweswariah when he was a young engineer in Bombay.

The Research Station of the Central Water and Power Commission at Poona has thus built up its reputation over a long period of nearly 40 years. It began its work modestly in 1916 as a Special Irrigation Division of the Bombay Public Works Department. Local problems of land drainage, reclamation and a study of the principles of water-flow (hydro-dynamics) engaged its attention. Soon, the Bombay Government found that the Research Division could put forth concrete solutions to problems, saving time and

money by largely eliminating doubts, indecisions, controversies and failures. The Division was promptly raised in 1920 to the status of a Hydro-dynamic Research Station.

At that time the models were situated on a distributary of the main Right Bank canal of the Mutha river near

Sir M. Visweswariah beside the Model of Automatic Gates
Designed by Him



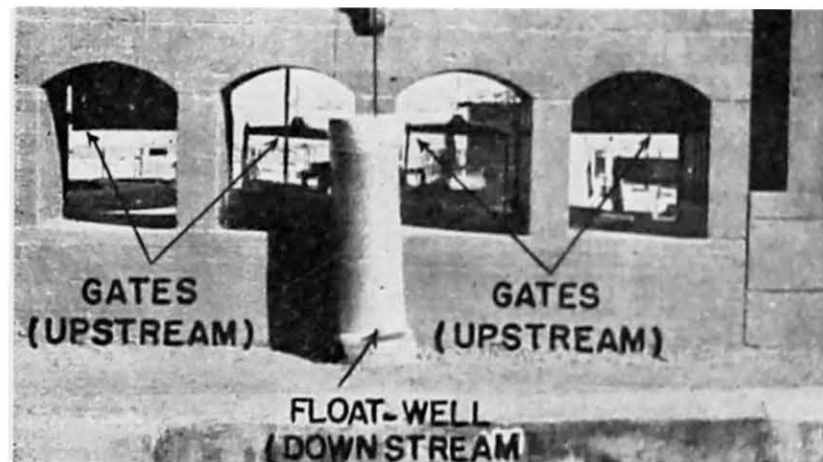
Hadapsar. Despite limited facilities it tackled problems connected with the design and construction of the famous Sukkur Barrage and its canals in Sind (then a part of Bombay Province). The success of the Station brought in its train increased demands for the solution of a wide variety of engineering problems. But the water supply for working models was inadequate at the distributary. Later models, therefore, began to be built from 1925 on the main Mutha canal below Lake Fife at Khadakvasla. By 1934 the entire Station moved over to the new site.

Twenty years of increasingly useful life showed that the foundations of the Research Station had been well and truly laid. By experimenting on scale models and perfecting the designs, it had saved crores of rupees in the construction of engineering projects in the country. The utility of the station was so indisputable and the demand for its services so wide that in 1937 the Central Government decided to take it over and extend its services to all the provinces and states in India.

New fields of irrigation and river-training research were added on, and the Station was renamed as the Indian Waterways Experiment Station. Ten years more of tackling problems from all over the country showed that it called for further expansion.

A scheme of reorganisation and establishment of new branches was accordingly sanctioned by the Central Government. The new branches of research include navigation, soils, materials of construction, statistics, physics, mathematics, and hydraulic machinery. Under this scheme the Research Station became, in 1948, a wing of the Central Water and Power Commission.

Except for the model research laboratory which calls

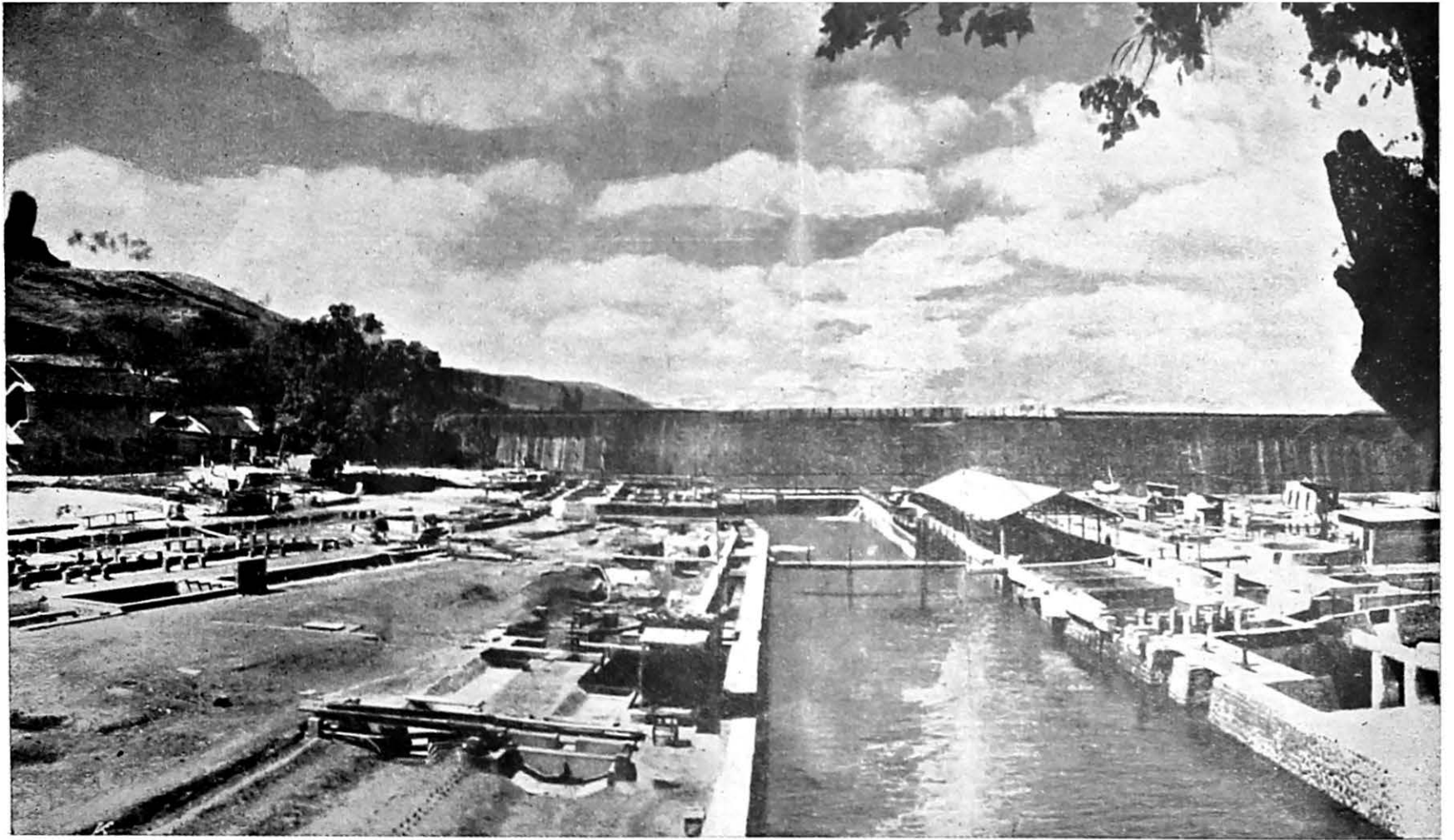


Model of the Automatic Gates for Khadakvasla Dam

for heavy and constant supplies of water the other sections are housed in Pooana itself. At Khadakvasla now design problems relating to most of the major river valley projects, harbours and estuaries are being solved through impressive, and sometimes ingenious, scale models. The Station is still undergoing a process of expansion in its various branches, and in a few years it will be ready to meet the large demands on its services in the East.

Automatic Gates Designed by Sir M. Visweswariah for the Khadakvasla Dam





Central Water and Power Research Station at Khadakvasla, Pooona

In the background is the Khadakvasla Dam with the Right Bank Mutha Canal flowing in the foreground. On either side are the various hydraulic models under test at the Research Station.

CHAPTER V

STUDIES AT THE STATION

THE more typical problems studied and solved at the Research Station will be of interest even to the non-technical visitor. The experiments on models are of course the more fascinating. But the researches in other related branches are no less vital for achieving economy and efficiency in engineering design.

During the last ten years alone, in the forty years of its life, the Central Water and Power Research Station has investigated nearly 200 important problems involving more than 3,500 experiments. These include measures for protection of bridges against outflanking, of weirs against breaches by floods, exclusion of sand and silt from irrigation canals, and training of rivers. The experience gained over the years on such problems is so considerable that the Station quite often suggests solutions off-hand without having to work out every problem on models. Models are now set up only for the solution of the more intricate and essentially new problems.

Model Investigations

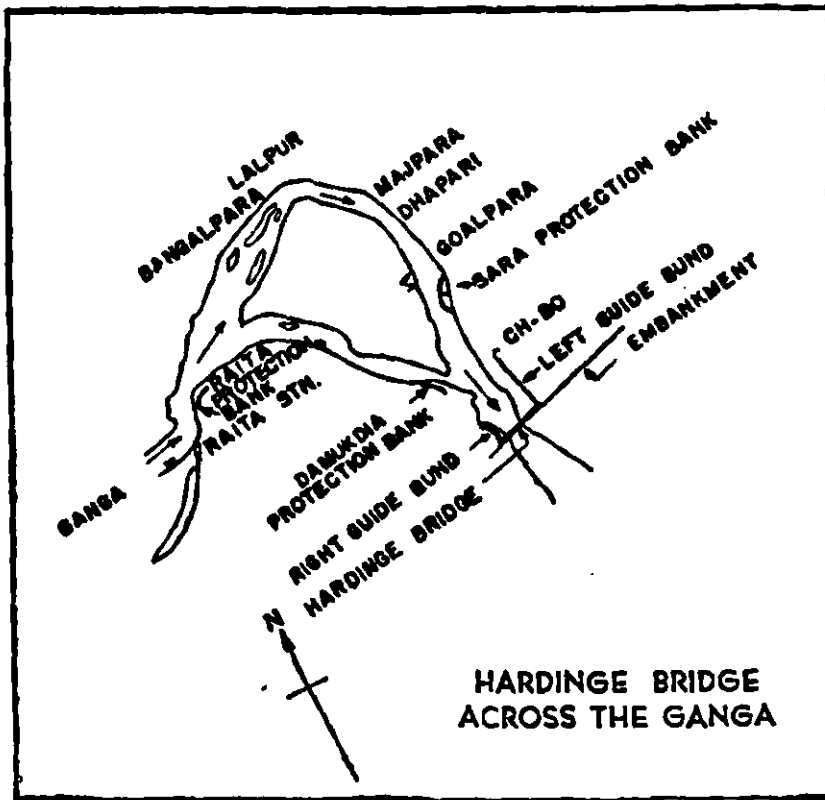
To go from the more simple to the complex :

Canals

Until a newly dug irrigation canal works well in practice, its successful behaviour remains largely a hope. A frequent source of trouble is the flow of sand into the canal which naturally reduces its capacity and its serviceability. The Mithrao canal in Sind fed by the Sukkur barrage system, and the canals of the *Dehri-on-Sone Anicut* (Bihar) suffered from this defect and were threatened with extinction. Here models helped.

It is indeed fascinating to watch the experiment on the models. The speed of water-flow at all depths in a stream is not the same; nor is the silt all of the same coarseness or held up in suspension at the same depth. The fine silt flows fast with the top layers of the stream, and the heavy grains move sluggishly along the bed. The fine silt is rich and nourishing and therefore welcome to the soil. The heavy silt on the other hand settles down and clogs the channels.

Plastic balls of different densities are used in the models to simulate the various grades of sand and silt. These show where silting occurs in each design, or for that matter, where erosion occurs, where eddies are formed, and so on.



An outstanding example of River Training Research carried out at the Poona Research Station is the case of the Hardinge Bridge across the Ganga. The story alongside shows how enormous damages can be caused by misplaced structures in river courses. Researches showed that the Sara Protection Bank which had been constructed 3 miles upstream of the Hardinge Bridge caused currents to undermine the guide bund supporting the bridge. Elimination of this bank saved the bridge from being quickly swept away by the fierce currents of the Ganga.

A striking result of these experiments was that, generally canals taking off from the bulging side of the bank silt up quickly, while those from the hollow side have a smooth run. On the basis of this and other information collected from the models, lay-outs were carried out which let in only the surface water containing fine silt into the canals.

Canal Outlets

Talking of canals and distributaries, the research men at the Station will tell you that they are sometimes called upon to tackle rather understandable human reactions. Where Government canals water the fields of farmers, there is often a temptation to tamper with the outlets to get more than one's fair share of water. The mischief will naturally tell against those who are down the line. A fool-proof outlet from the canal is the obvious indication.

The Research Station has worked out improvements on certain old devices. These modules guarantee a certain flow to the field, and no more. Made of concrete, they are not easily fiddled with without visible damage. These have been adopted in the Punjab and in the Bombay State.

Bridges

The rivers in the soft alluvial plains of the north sometimes play dangerous tricks by changing their courses at spots where they should not. Causes have to be looked for and remedies suggested to make them behave themselves.

About 200 miles north of Calcutta lies the mile-long Hardinge Bridge across the vast Ganga. This was built in 1915 at a cost of Rs. 5 crores to carry the Assam-Bengal

railway. Loose stone walls for some distance on either bank of the river supported the bridge. This was to stabilise the channel of the river at the site. And it did, until in 1933 a slip occurred in the right wall. That was the signal for quick and further attack. Soon the river threatened to outflank the bridge.

Frantically rocks were dumped into the gap, and the rout was just staved off. And at what cost! Merely for the palliative treatment a crore of rupees had been spent.

The Poona Research Station laid the Ganga Model, covering all the features for some miles up and downstream of the bridge. Ultimately the villain of the piece was spotted.

On the left bank of the Ganga about three and a half miles above the Hardinge Bridge had been built a protection bank—the Sara protection bank—which turned the high velocity flow of the river to a fierce eddy down the river at the bridge site. This undercut the right stone guide bund and caused a serious slip. And the entire process had been abetted by another protection bank, the Damkudia guide bank, on the right side about two miles upstream of the bridge.

The Station worked out a number of measures, but the cheapest was the elimination of the Sara protection bank. By adopting this measure, the research men had predicted, the attack on the right bank would cease in about eight years. They were off the mark by just one year—it took nine years.

Spillways and Siphons

Dams are built to stand the pressure of a calculated depth of water in the reservoirs behind them. During

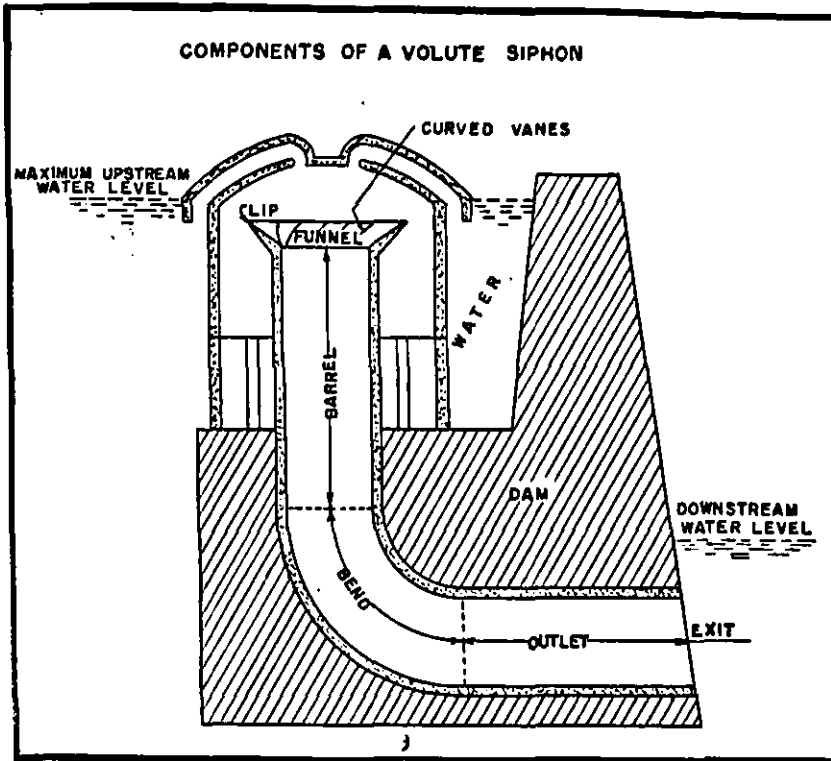
flood time the huge quantity of excess water has to be cleared off promptly. Various devices are used for this purpose consistent with safety and economy. These are, sluices at the foot of the dam, or sections of the dam built to the calculated height so that any water above that level would smoothly spill over it to the channel downstream, or pipes running from the reservoir through the dam so that the surplus water above the open mouth of the pipe automatically drains down to the other side of the dam, or bye-channels cut from the reservoir round the end of the dam to discharge the flood into the stream below the dam, or any combination of these devices.

The discharge through an outlet is clearly a function of the depth of water and the dimensions of the outlet. But it happens that a sluice or a siphon never discharges the theoretical maximum volume; and it is the ambition of every engineer to raise the actual outflow as close as possible to the calculated figure, for, the greater the discharge from an outlet the less the number of outlets to be constructed for flood discharge.

Mr. Ganesh Iyer, an Indian engineer, has devised an ingeniously simple modification of the siphon, which considerably boosts up the volume of flow.

The siphon is a bent concrete pipe with a funnelled mouth, carrying curved guide vanes on the lip to cause a swirl of the in-rushing water. Over the funnel, and quite clear of the lip, is a concrete cap supported on pillars, extending below the lip of the funnel.

As the water in the reservoir rises above the funnel lip, it spills into the siphon and causes a vortex because of the curved vanes. And the vortex sucks in the limited



Ganesh Iyer Siphon

The ingenious improvement introduced by the Indian Engineer, Mr. Ganesh Iyer, has stepped up considerably the rate and volume of water discharge from reservoirs.

quantity of air imprisoned in the cap above the water level. With a vacuum thus created at the mouth of the siphon, atmospheric pressure around the cap pumps in much more water than if the cap were not there. The difference in the volume of discharge at the outlet of the siphon, with and without the cap, is indeed remarkable. In other words,

with the Ganesh Iyer Siphon, fewer siphons are to be built for achieving a given outflow in the same period.

The new siphon has not only been successfully adopted in some of the recent dams like Hirebhaskar in India, but it has also earned the praise of American engineers.

There are, however, certain snags. When the siphon is fully discharging, vibrations are sometimes set up, air explosions occur in the pipe, and the walls of the siphon are eroded in places. The causes and remedies are under active investigation at the Research Station.

Navigation

Some of the most baffling problems that have so far defied solution are those of the navigability of harbours and estuaries. The problem is essentially one of shifting channels and shoal formations. Constant and costly dredging is involved in maintaining the navigability of the channels. The attempt is therefore to work out measures which would enable the channel to be maintained more or less automatically. But that is not easy, because most devices that work with one-way rivers are not suitable for the two-way flow in harbours and estuaries; for, what is done by the flood is often undone by the ebb of the current from the sea.

Hooghly Estuary

Among the navigational problems that are under study at the Station, the most complicated is that of the Hooghly. Every year 40 lakhs of rupees are being spent for silt and sand removal from ship channels between Calcutta and the sea. An unceasing watch has to be kept on the depth of

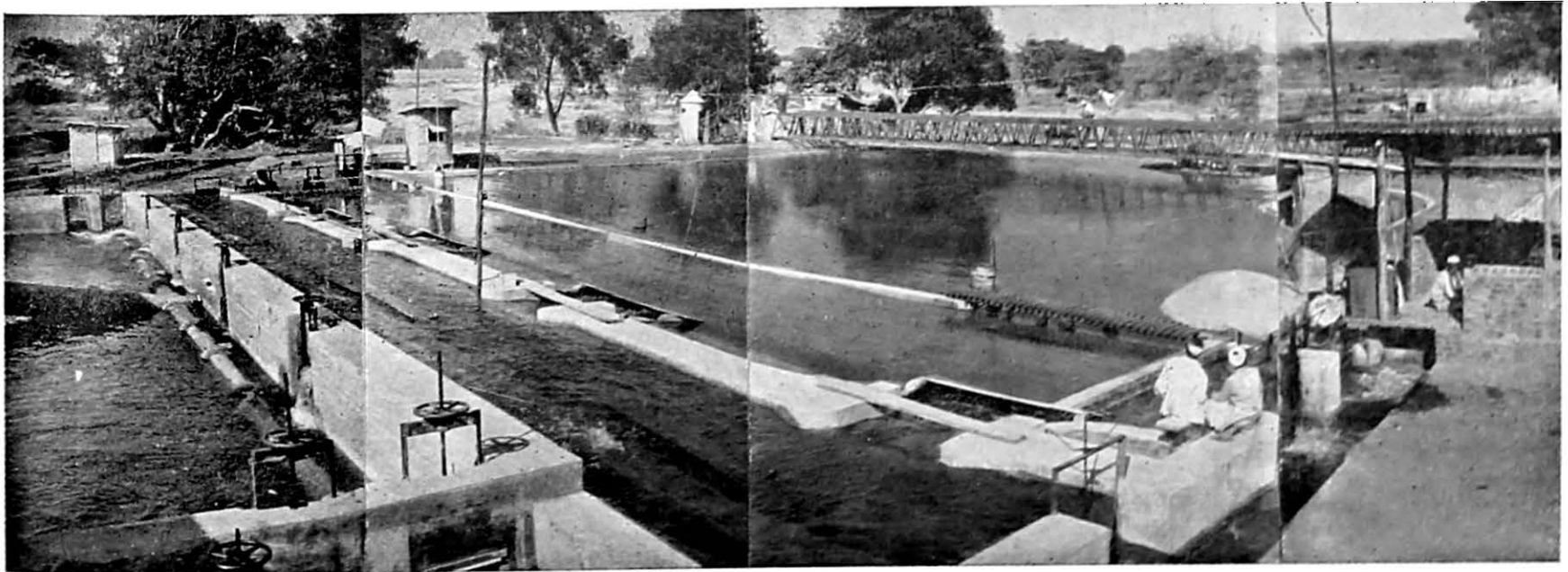
the tortuous course; and there are reaches where the silting, and therefore the dredging, never stops.

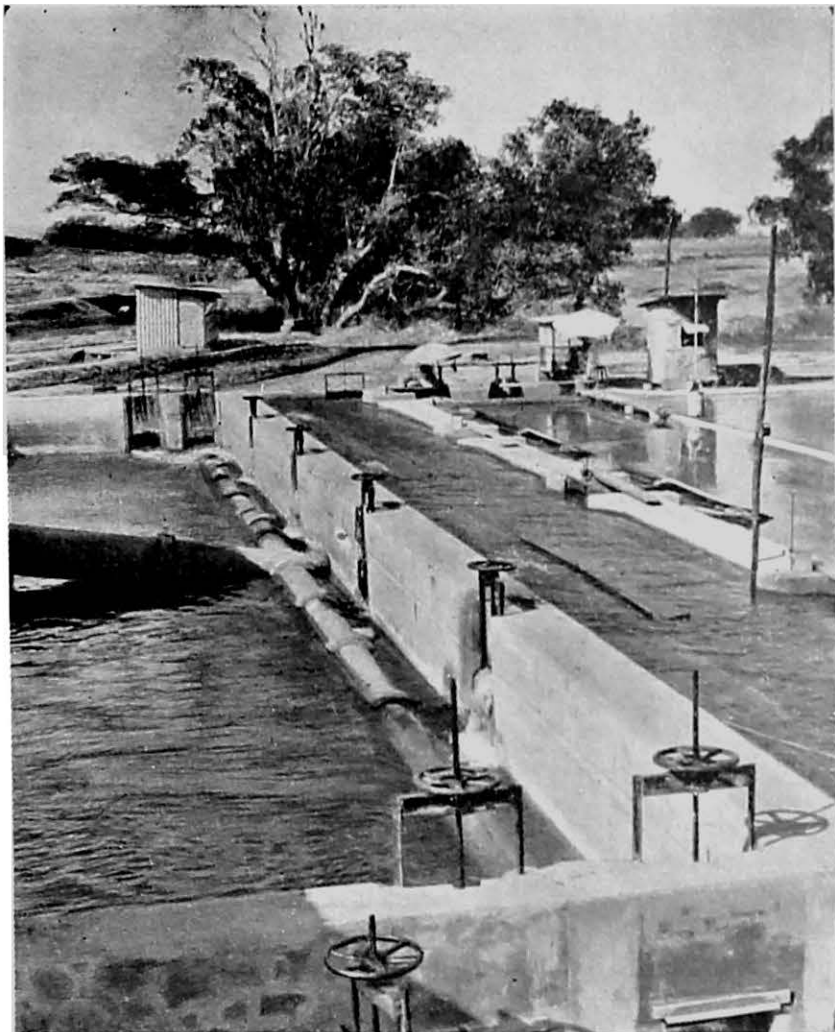
Of the 100-mile stretch between Howrah and the sea, it is the earlier half that calls for very vigilant negotiation by ships. The Hooghly point, below the entries of the Rupnarain and the Damodar, off the James and Mary sands, can perhaps be more fittingly called the *Risky Point*; many a ship has found its watery grave near about this spot.

The silting, shoal-formation and the dredging of the river are, to simplify the problem and present it rather

roughly, the result of the uneven flow of water up and down the estuary. For eight months in the year, except during the rainy season, the flood tide from the sea is overwhelmingly more powerful than the normal river flow in the opposite direction. The salt water and the sand that rush up the channel recede only half as fast during the ebb tide. That gives the sand a chance to settle down along the course. But the sedimentation on the bed is not uniform either, for the numerous curves slow down the flow and silt up on one side while the opposite bank is scoured out. In certain

Hooghly Estuary Model at Khadakvasla
In the left is the tide-generating apparatus.





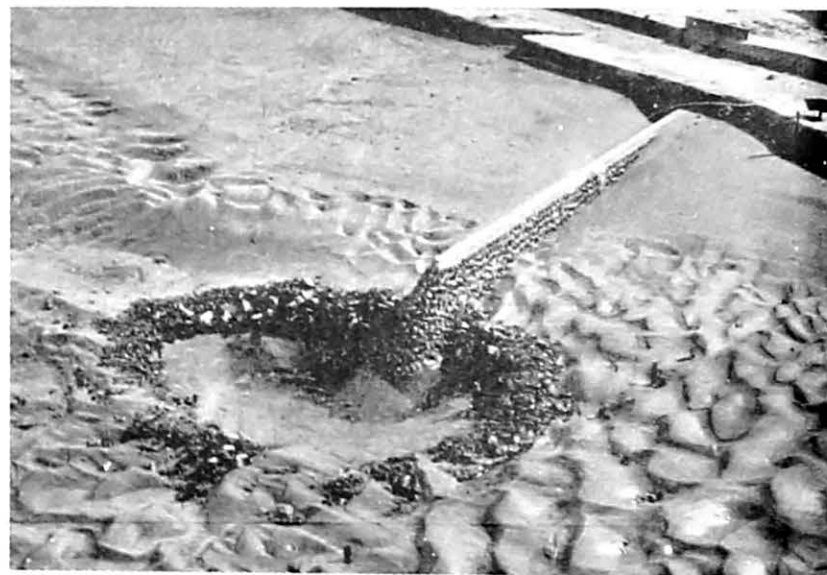
The Close-up of the Wave-generating Mechanism of the Hooghly Port Model

The Close-up of the Sankrail Spur →

The effect of the proposed spur is clearly seen in the picture



The proposed Sankrail Spur in the Hooghly Port Model



stretches of the river, the flood tide runs along one bank and the ebb tide along the other. All these complicated movements of water create sand shoals as well as dangerous eddies and shift the river course. Over the years some of the active wharfs had to be abandoned because of silting, and a number of others are under constant dredging.

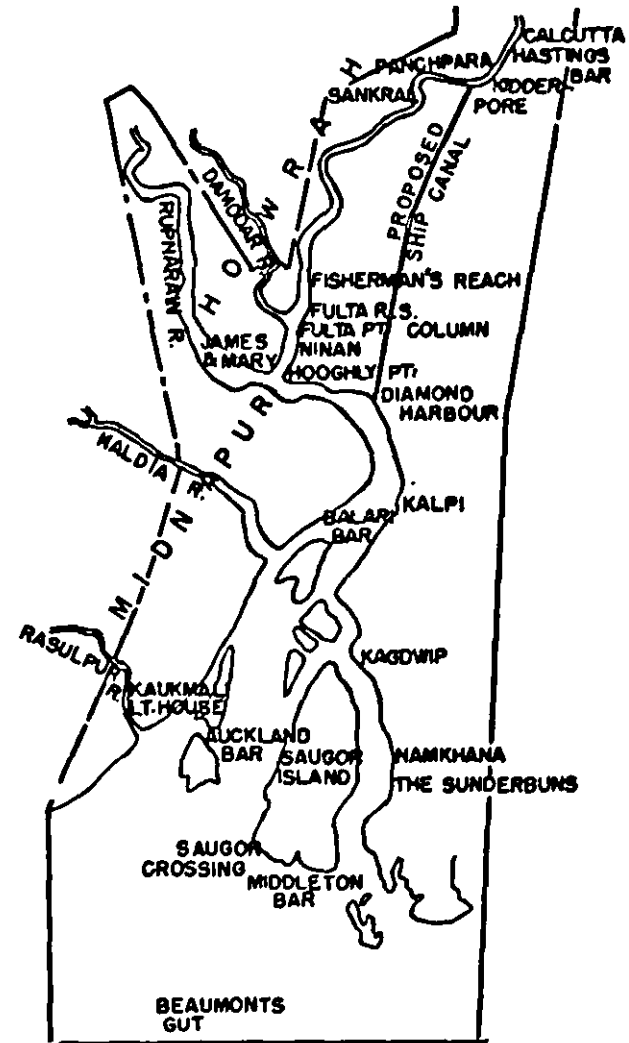
Normally ships should not take more than ten hours to cover the 100 river miles from Calcutta to the sea. But the tortuous course and the sand bars stretch it anything up to three days. The 34-mile reach from Calcutta to Hooghly Point is particularly difficult, and ships have to wait for high tide to sail this stretch.

In sheer desperation the Calcutta port engineers suggested a straight and narrow canal between Calcutta and Diamond Harbour—a distance of 40 miles. But the cost of the scheme is prohibitive. In 1946 it was estimated to cost 15 crores of rupees. The Central Water and Power Research Station has therefore been put on the job of looking out for solutions, equally effective but not so expensive as the canal project.

The first, and perhaps the biggest, problem was the erection of a model, true to the original. Unless the model could simulate to a reasonable degree the force, direction and path of the flood and ebb tides, the tendency for formation of sand bars at corresponding points and the rest of the relevant details, there could obviously be no attempt at a solution of the Hooghly problem at all.

The model was built to scale, and a tide-generating apparatus was designed and erected at the Station itself. After more than 18 months of repeated trials the model has been proved. The reproduction of the salient features is so exact that even the bore tide which follows the ebb

FEATURES OF THE HOOGLHY & PROPOSED SHIP CANAL

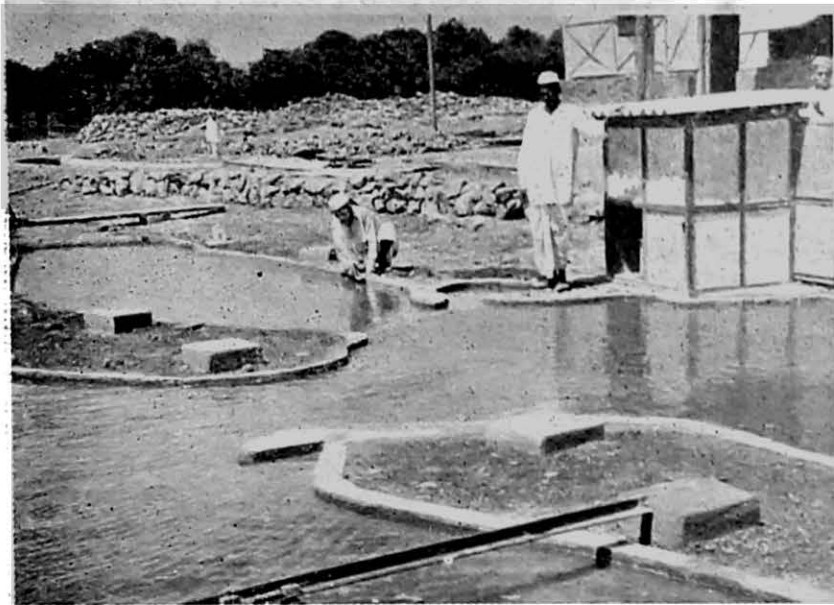


tide after predictable intervals, occur in the model with amazing accuracy. The sand islands in the channel and the eddies in the James and Mary's reach are all there in miniature.

Various proposals of engineers put forward in the history of the Calcutta Port Trust as well as of the research workers at the Station are all being put to test. They will stand or fall according to the model results.

The experiments on the models have already started yielding promising results. An oblique spur of 1,300 feet thrown from a selected spot on the bank in the Sankrail reach has succeeded in routing both the flood and ebb tides

Model of the Mangalore Port at Khadakvasla



along the right bank instead of on opposite banks. In other words, ships will be assured of a constant, perennial channel in that reach without the labour of dredging.

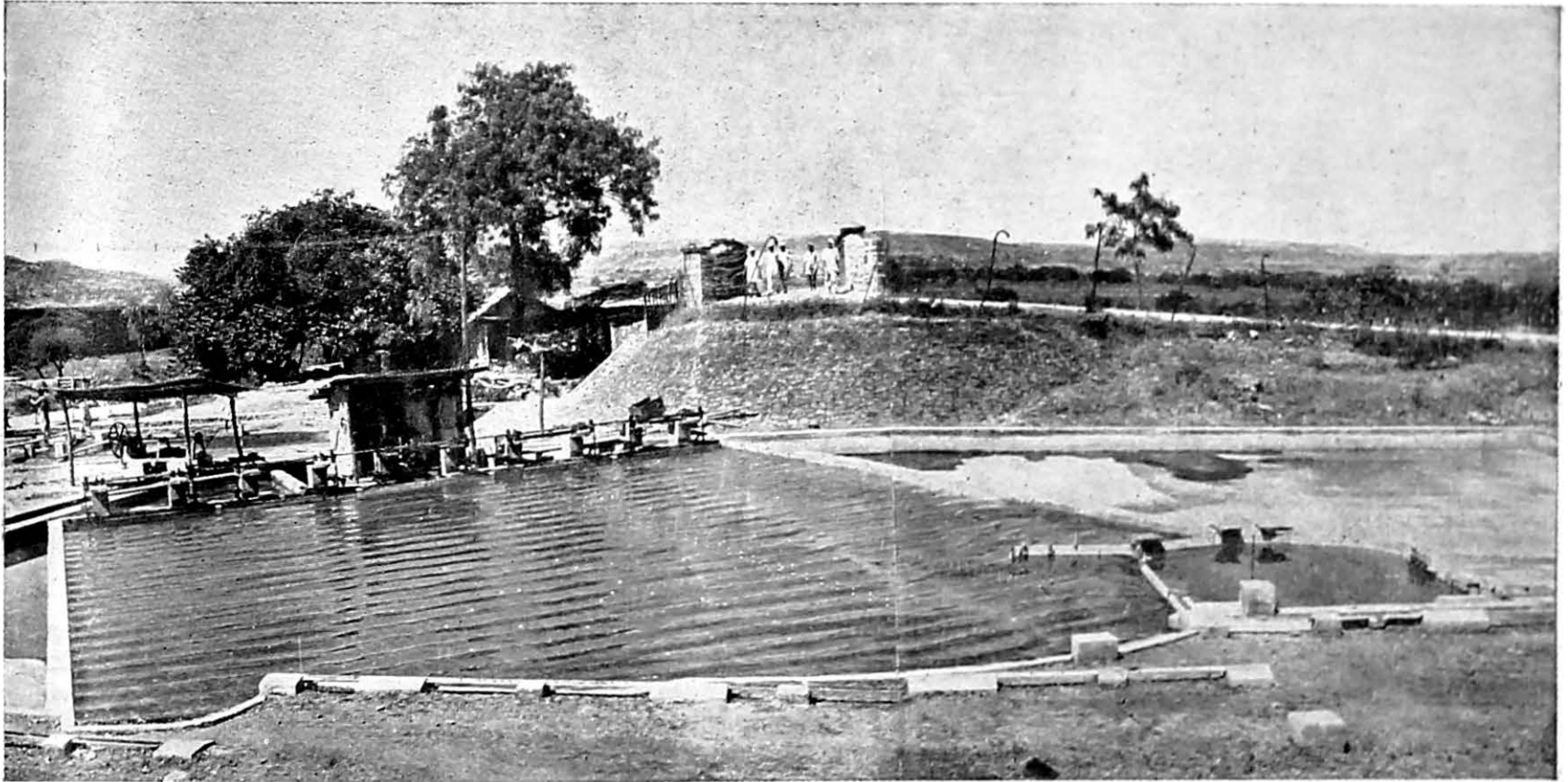
The Hooghly Expert Committee appointed by the Government to examine the problems and solutions for the navigability of the estuary has recommended the construction of the spur in the Sankrail reach.

Somewhat less complicated, but equally vital to the nation, are the problems of the Madras, Mangalore, Kandla and Cochin harbours that are being investigated at the Station.

Madras Harbour

Madras has no natural harbour. Quay walls have been built to enclose 200 acres of sea for ships to enter and load or unload their cargo. The problem is the turbulence in the harbour caused by cyclonic storms. When the storms are severe ships have to stand out to sea to avoid knocking each other in the harbour.

Experiments on a true-to-scale model showed that the incoming waves reflected back by the quay walls into the harbour clashed with fresh waves from the sea to cause the turbulence. The solution was therefore clear—stop the strike-back of waves from the harbour walls. In other words, find a way of dissipating the surplus wave energy at the quay walls. After a number of trials a sloping, stony beach at the foot of the walls was found to use up the wave action, leaving very little to clash with the incoming waves. Of all the measures that could be thought of, the spending beach was found to be the least expensive too.



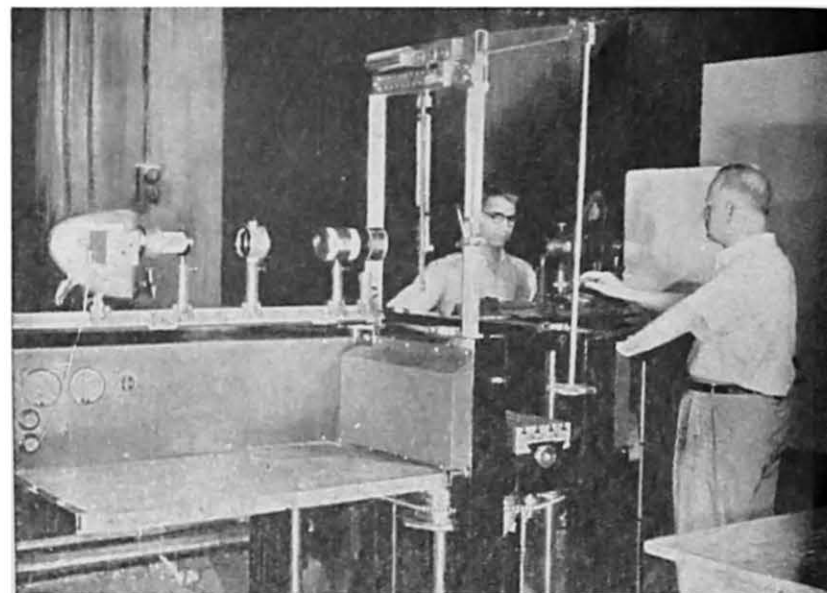
The Madras Harbour Model

At the right end of the picture is seen the Madras Harbour. The wave-generating apparatus is seen at the back in front of the hut. Spending beaches against the quay walls of the harbour in the model promise considerable reduction of turbulence in the harbour.

The Poona Laboratory

Apart from the models, extensive research is carried on by the Station on various subjects related to sound

engineering construction. The suitability of indigenous soils as binding material, as load-bearers or for soil cement; analysis of the geological structure of dam sites by creating



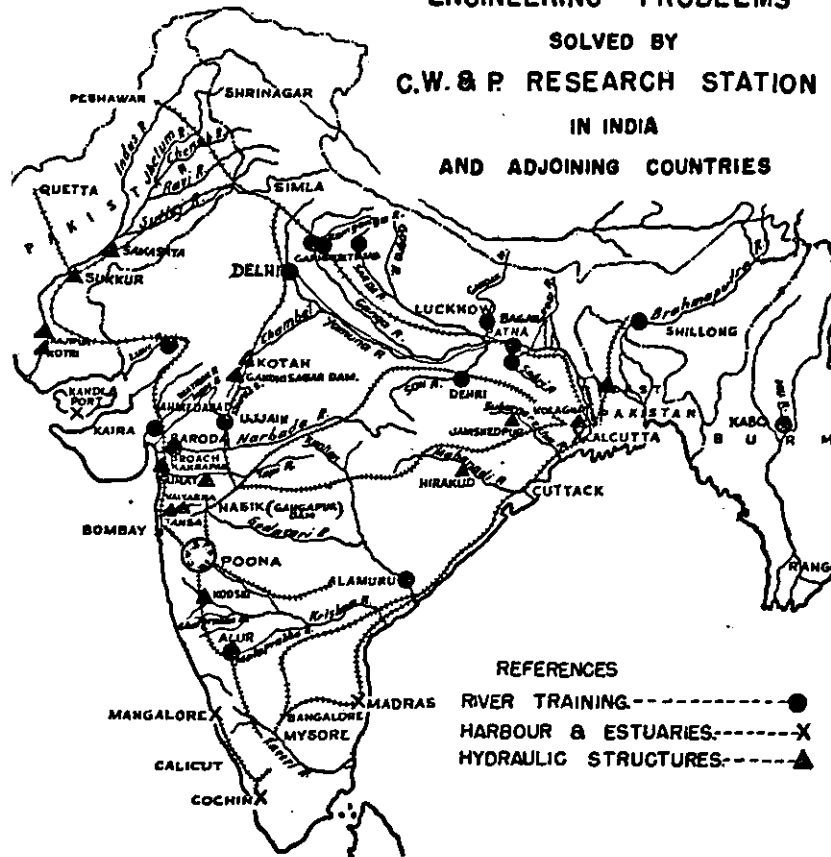
Apparatus for Determining Stress Distribution in Structures

light, artificial earthquakes; the lines of stress and strain in various designs of structures through the use of Bakelite models and polarised light; the statistical estimation of water-flow in river channels from their catchments are some of the subjects that are under constant study at Poona. They are all aimed at the improvement of designs of new

structures or of old ones that are threatened with danger.

The application of the research results thus collected over the years has not only contributed in money—which itself perhaps runs into millions of rupees—but to the total national wealth which naturally accrues from sound designs and robust structures executed with efficiency and economy.

**ENGINEERING PROBLEMS
SOLVED BY
C.W. & P. RESEARCH STATION
IN INDIA
AND ADJOINING COUNTRIES**



AN INSPIRATION TO OTHERS

The pioneering work and ever-expanding activities of the Central Water and Power Research Station have provided a model for a number of other organisations in the country. Research Stations have sprung up in Madras, Mysore, Punjab, Bengal, Uttar Pradesh and Hyderabad to tackle the numerous engineering problems that crop up continuously in each State. The role of research has now come to be so much appreciated that the larger river valley projects in the country have set up their own laboratories at the project sites to enable the execution to be carried out with speed, precision and economy without sacrifice of strength or quality.

The services of the Central Water and Power Research Station have been extended beyond the frontiers of India. On the basis of model experiments at Poona on the Ye-U Canal taking off from the Mu river in Burma, measures have been recommended to exclude sand from this important irrigation canal. Thus through its growing activities and its steady service, the Central Water & Power Research Station has well established its claim to be the largest engineering research organisation in the East.

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