Government of India
Ministry of Water Resources
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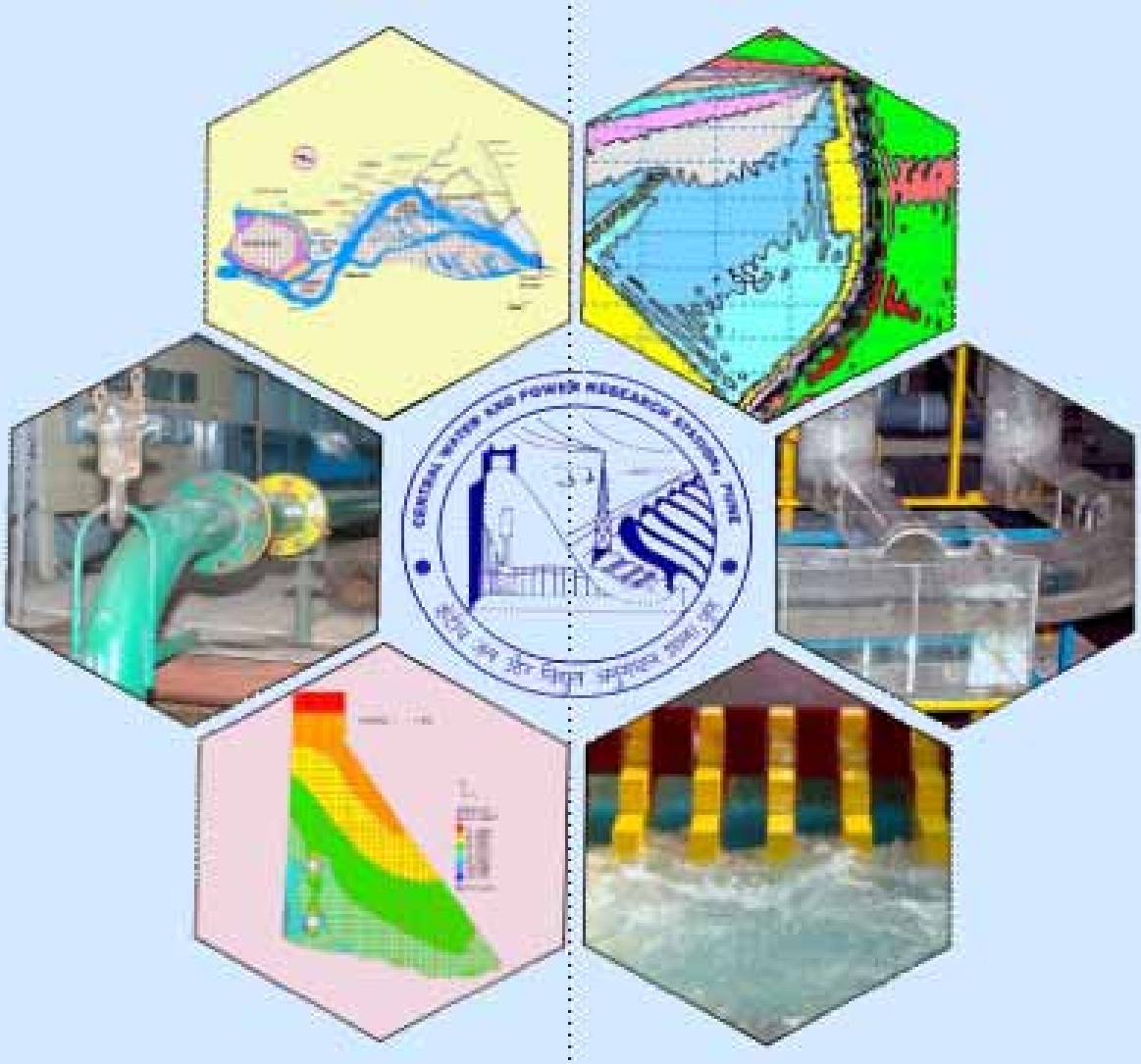
CWPRS Annual Report 2010-11



CENTRAL WATER AND POWER RESEARCH STATION

PUNE – 411024, INDIA

Flag Hoisting by Dr. I.D. Gupta, Director on Republic Day 2011

Communal Harmony Week Celebrated from 20 August to 03 September 2010

ANNUAL REPORT 2010-11

CENTRAL WATER AND POWER RESEARCH STATION, PUNE

FROM THE DIRECTOR'S DESK

It gives me immense pleasure to present you the CWPRS Annual Report 2010-11; highlighting the activities and achievements of CWPRS during the year. The emphasis has been mainly on applied research to solve specific problems pertaining to water resources development projects, river training and protection, hydroelectric/ thermal/ nuclear power projects, and design of coastal and offshore engineering structures. The tools applied for this purpose have been the physical hydraulic models, mathematical models, and field and laboratory experiments. The recommendations given on the basis of the studies carried out had helped in evolving efficient designs for hydroelectric projects, ports and harbour structures and in finding solutions to river engineering problems.

During 2010-11, more than 95 applied research projects were completed, and the reports submitted to the respective project authorities. Summaries highlighting the findings of important studies are presented in the report under the Section R&D; classified into seven major disciplines of the expertise of CWPRS.

More than 35 studies were completed in the major areas of river engineering, river and reservoir systems modelling and the dams and appurtenant structures. Notable among them are: hydraulic model studies for Umtru, Kotlibhel, Kishanganga and Pare dams, morphological studies for Ganga near Farakka barrage, sedimentation analysis for proposed pumped storage scheme at Malshej Ghat and for Road Bridge at Zadeshwar, water quality assessment for Sardar Sarovar reservoir, physical model studies for tail race system of Chhukha HE project, spillway/power intake for Kotlibhel HE project and shore protection measures for Kakrapar atomic power plant. Also reported are studies relating to designing intake for proposed thermal power station at Solapur, area drainage studies for BRBC thermal power project at Nabinagar, and extreme value analysis of hydrometerological data for proposed nuclear power projects at Chutka and Jaspara.

A wide range of studies were also conducted for various coastal and offshore engineering projects in the country. Notable among such investigations undertaken are: design of breakwaters at Butler Bay and for mega container terminal at Chennai, wave flume studies for design of Groynes at Nandgaon, mathematical modelling studies for: development of ship building yard near Cuddalore; fisheries harbours at Thanur, Muthalapozhy, Parappanangadi and Karanja; and Porbander, Jawaharlal Nehru and New Mangalore ports. Summary notes describing 34 important investigations in the area are reported.

About 27 studies were also conducted in allied areas like Foundation and Structures, Applied Earth Sciences, and Instrumentation and Calibration Activities. Some of the significant studies can be listed as: seismological investigations for Harangi and Middle Vaitarana dams, tracer studies for delineation of seepage paths at Dudhganga dam, estimation of site-specific design seismic parameters for Dagachhu project, underwater repairs to Ukai power canal, analysis of dam instrumentation data for Indirasagar project, and dynamic response analysis of Middle Vaitarana dam.

Dissemination of the research findings has been also an important activity during the year. CWPRS officers published a total of 96 research papers in different journals and seminars/symposia/conferences and participated in 23 technical events. Eleven training

programs were organized on specialized topics, in addition to delivering 53 lectures at other organizations. CWPRS has also contributed significantly by participation in Expert Committees and in developing and revising the ISO and BIS standards. As is the case every year, the institution had a galaxy of visitors during 2010-11. Selected photographs in this respect are added in the report.

Use of official language Hindi is pursued and encouraged resolutely on a day-to-day basis. Hindi Pakhwada was organised at CWPRS during 1-14 September 2010 to encourage accelerated use of Hindi in official communications; with 14th September 2010 celebrated as Hindi Day. During Hindi Pakhwada, a number of competitions were arranged which included essay competition, debate, vartalap and typewriting. The winners of various competitions were awarded prizes on the Hindi Day.

I am sure that you will find this report highly informative and useful. I acknowledge with thanks the efforts put in by the concerned staff in compiling this volume in time.

Dr. I.D. Gupta

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ABOUT THE INSTITUTE

General

The Central Water and Power Research Station (CWPRS), Pune, as the institution is known today, was established in 1916 by the then Bombay Presidency as a Special Irrigation Cell, with the limited mandate to modify and alter the then existing agricultural methods of the region to meet irrigation limitations. Recognizing its role in the systematic study of various phases of water flow, including floods, the institution was taken over by the Government of India in 1936. With the dawn of independence, and launching of planned development of water resources of the nation, CWPRS became the principal central agency to cater to the research and development (R&D) needs of hydraulics and allied disciplines for evolving safe and economical designs of hydraulic structures involved in water resources projects, river engineering, power generation and coastal engineering projects. Today, as a part of the Ministry of Water Resources (MoWR), the mandate of the institution encompasses undertaking specific research studies supported by necessary basic research. Comprehensive R&D support is offered to a variety of projects in fields as diverse as river training and flood control, hydraulic design of bridges, design of hydroelectric structures, harbours, waterways and coastal protection, structural design, foundation engineering, pumps and turbines, ship hydrodynamics, earth sciences, reservoir sedimentation, cooling water intakes, discharge of industrial effluents and hydraulic instrumentation.

Advisory services are offered to the government within the sphere of its activities by participation in various expert committees. Disseminating the research findings amongst hydraulic research fraternity, and promoting research activities at other institutions by imparting training to their research manpower, are also undertaken.

CWPRS campus, situated downstream of Khadakwasla dam near Pune, occupies an area of about 400 acres, where basic research infrastructure available include: water re-circulation system for physical models, workshop, library, computers and communication facilities, auditorium and housing facilities. The solutions offered by CWPRS are based on the investigations from physical and mathematical models, field investigations coupled with desk studies or from a combination of these. The institution also carries out collection and analysis of field/ prototype data on a variety of engineering, hydraulic and environmental parameters.

The research activities at CWPRS can be grouped into seven major disciplines as listed below.

- River Engineering
- River and Reservoir Systems Modelling
- Reservoir and Appurtenant Structures
- Coastal and Offshore Engineering
- Foundation and Structures
- Applied Earth Sciences
- Instrumentation, Calibration and Testing Facilities

CWPRS has been recognized as the regional laboratory of the Economic and Social Commission for Asia and the Pacific (ESCAP) since 1971. The institution, with multi-disciplinary approach in its activities, thus represents unique services available to the country and the ESCAP region.

Organizational Set-up

CWPRS is a subordinate office of MoWR. The Director is the Head of the Organization. The Chief Administrative Officer is designated as the Head of Office. The total sanctioned staff strength of CWPRS, is 1,169. The research cadre, comprising a sanctioned strength of 358 personnel in different categories, is supported by technical, auxiliary technical, administration, accounts and ancillary services. A Governing Council (GC) and a Technical Advisory Committee (TAC) render advice to the Ministry regarding functioning of CWPRS.

Governing Council

The GC functions as an overall policy making body for CWPRS under the Chairmanship of the Secretary, MoWR. The GC comprises members from the Finance and Administrative Wings of MoWR, Planning Commission, User Organizations, State Governments and Non-Government Officials. Apart from laying down broad policy guidelines, the GC monitors the overall progress and performance of the institution. Other functions of GC include scrutiny and monitoring of expansion programmes, annual and five-year plans, budgetary allocations, creation and abolition of work disciplines, review of manpower requirements and delegation of additional powers.

Technical Advisory Committee

The TAC, chaired by the Chairman, Central Water Commission, is primarily intended to assist the GC in the matters of R&D and associated technical programmes. The Committee, inter alia, scrutinizes and recommends the expansion and research proposals under the five-year plans, suggests programmes for training of manpower and provides guidance in formulation of collaborative arrangements and Memoranda of Understanding with other agencies/ institutions.

Budget and Programme Committee

The Budget and Programme Committee (BPC) assists the GC in formulation of budget proposals. The terms of reference of the Committee include: monitoring progress in implementation of the approved programmes and utilisation of the sanctioned budget, and linking programmes and budget closely so as to facilitate preparation of a proper performance budget. The Director, CWPRS, is the chairperson of the BPC; with the Finance Officer being the Member Secretary.

RESEARCH AND DEVELOPMENT

GENERAL BACKGROUND

CWPRS is engaged mainly in project specific research to evolve safe and cost-effective designs of hydraulic structures involved in development of water resources, river engineering, power plants, and coastal engineering projects. Physical and mathematical model studies coupled with field and laboratory experiments are carried out for this purpose in the seven major areas of expertise of CWPRS. During the year, a total of 95 technical reports on the recommendations were submitted to the concerned project authorities on completion of the studies. References were received mainly from Central/State Government Organizations, Public/Private Sector Agencies, Port Trusts, Municipal Corporations, etc. Several studies were also carried out for neighbouring countries like Bhutan, Afghanistan, Nepal, etc.

This section gives brief summaries of all the studies carried out during the year. The studies are classified into seven major disciplines at CWPRS as follows:

1. River Engineering: River Engineering mainly deals with river training and bank protection works, hydraulic design of barrages and bridges, and location and design of water intakes using morphological studies. Field studies for measuring water and sediment discharge in rivers and canals are also conducted.

2. River and Reservoir Systems Modelling: Hydrologic and meterologic studies are conducted to estimate extreme values of various parameters such as rainfall, temperature and humidity. Flood estimation and forecast, reservoir sedimentation and water quality studies are carried out using mathematical models and field surveys.

3. Reservoir and Appurtenant Structures: Spillways and Energy Dissipators are studied on physical models. Water conductor systems including head race and tail race channels/tunnels and surge shafts are studied on both physical and mathematical models. Studies are carried out on physical models for desilting basins, sedimentation and flushing through reservoirs, sediment exclusion devices. Sedimentation in reservoirs is also assessed through remote sensing.

4. Coastal and Offshore Engineering: This discipline deals with optimization of location, length and alignment of breakwaters, jetties, berths, approach channel, turning circle etc. for development of ports and harbours. Estimation of siltation in harbours, their disposal and sand bypassing, location of sand trap and hot water recirculation studies are carried out using both physical and mathematical models. Suggesting suitable coastal protection measures based on locally available materials is an important activity of the group.

5. Foundation and Structures: Laboratory and field tests are carried out to determine soil, rock and concrete properties. Mathematical modelling as well as experimental studies are conducted for studying the stability and structural safety of dams and appurtenant structures. Field studies are carried out for assessing the health of hydraulic structures and suggesting suitable repairing measures.

6. Applied Earth Sciences: Seismic surveillance of river-valley projects, assessment of site-specific design seismic parameters, controlled blasting studies for civil engineering construction sites, evaluation of quality of concrete and masonry is done by non-destructive methods and estimation of elastic properties for foundation of massive structures for geophysical methods are the main activities of this group.

7. Instrumentation, Calibration and Testing Facilities: Hydraulic Instrumentation is used for data collection on physical hydraulic models. Field data collection is carried out on coastal parameters like water level, velocity, wave-height etc. A Random Sea Wave Generation (RSWG) system is used for wave flumes and basins. Dam instrumentation is provided on prototype. Current meter and flow meter calibration facilities are also available, which are used extensively.

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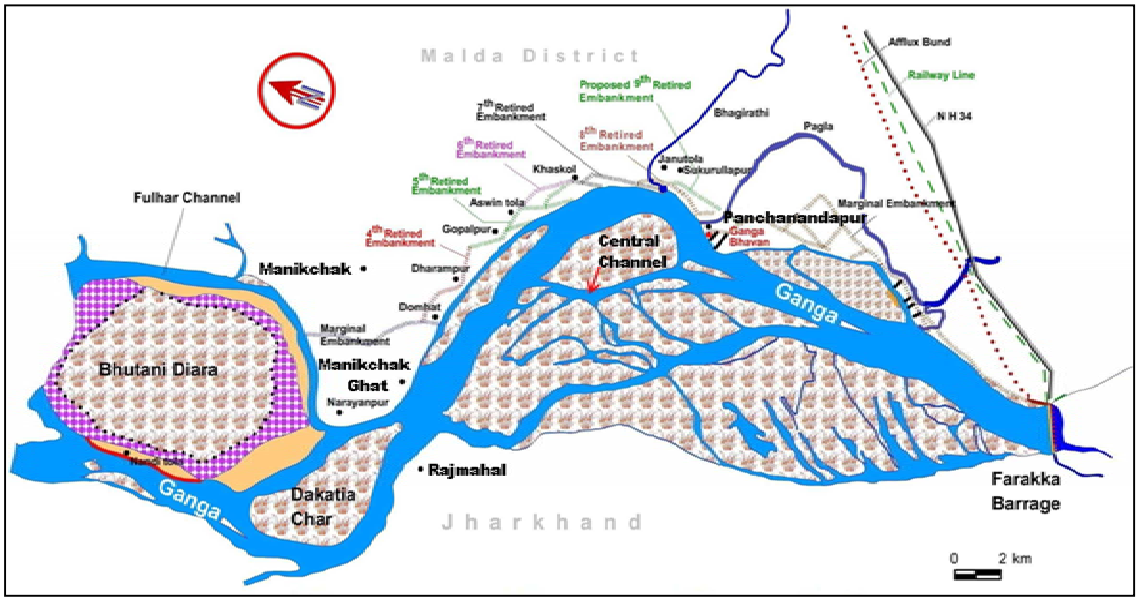
RIVER ENGINEERING

MORPHOLOGICAL STUDIES TO IMPROVE THE BEHAVIOUR OF RIVER GANGA ON UPSTREAM OF FARAKKA BARRAGE, WEST BENGAL

Erosion on left bank of river Ganga in the Panchanandpur area, upstream of Farakka barrage, had been a matter of concern in the past. Various proposals to abate fury of the river in the reach have been put forth by the Technical Advisory Committee (TAC) of Farakka Barrage Project from time-to-time. Morphological studies were conducted by CWPRS to understand the siltation/erosion phenomena in the affected area and to suggest necessary protection measures.

Detailed analysis of satellite imageries of Farakka region for the period 1975-2009 showed that the bank erosion near Panchanandpur has reduced of late; and the central Ganga channel is now fully developed. For safety of the left guide bund, close monitoring of flows during floods is considered necessary. The existing protection works may also need to be strengthened. Maximum bank erosion for a length of about 1,350 m took place during 1998-2009 along the right bank near Radhanagar, at about 8 km upstream of Farakka Barrage. This in turn helped to create favourable flow conditions in Panchanandpur region. However, this phenomenon may lead to increased flow intensities towards the right bank.

The shoal formation along the right bank at about 1 km upstream of the barrage, which started in the year 2006, has shown diminishing tendency. However, the shoal is noted to be advancing towards the head regulator near the barrage. Hydrographic survey at regular intervals may help assessing the status of progress of the shoal. The present trend shows that the river has a tendency to cause erosion at left bank near Manikchak/ Domhat area about 28 km upstream of barrage. Close monitoring of the river behaviour in this area was recommended during flood periods.

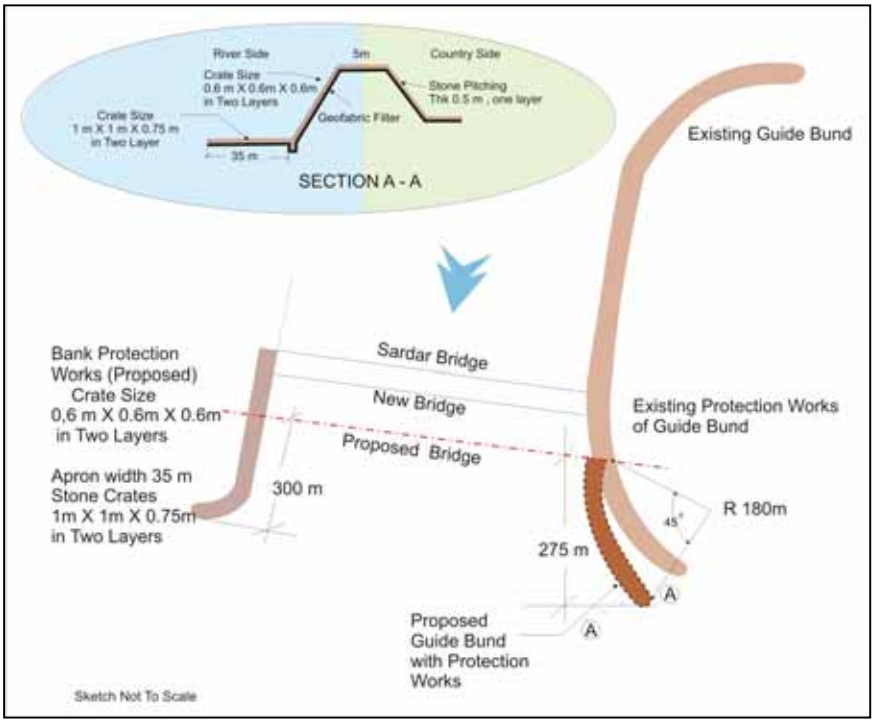


River Ganga Upstream of Farakka Barrage

STUDIES FOR FINALIZING THE LOCATION OF PROPOSED ROAD BRIDGE ON NH-8 ACROSS NARMADA AT ZADESHWAR, GUJARAT

The two-lane Sardar Bridge on the Surat-Mumbai stretch of NH 8 was constructed in 1977. Subsequently, an additional two-lane bridge was constructed during 1999-2000 at 29 m downstream of the Sardar Bridge. As the Sardar Bridge is not found suitable for heavily loaded vehicles, and the volume of traffic on NH 8 is very high, the National Highway Authority of India (NHAI) has proposed to have a uniform corridor of six lanes for smooth and uninterrupted movement of traffic. This will need construction of another four-lane bridge on the downstream of the existing bridge or two two-lane bridges, one on its either side. To decide a suitable configuration, NHAI desired CWPRS to conduct the necessary studies. Morphological studies indicated that, Narmada in the vicinity of Zadeshwar does not have any tendency of shifting channels. Moreover, analysis of satellite data revealed that the waterway of the existing bridges is adequate. Based on site inspection, satellite imageries and desk studies, the following further recommendations were made:

- The proposed site, about 100 m downstream of existing bridges, is suitable for locating the new four-lane bridge from hydraulic consideration.
- The water way of 1,346 m is adequate for the proposed bridge.
- Construction of a downstream guide bund of length 275 m having curved head of radius 180 m and angle of sweep of 450 is recommended along with suitable bank protection works on the left side.
- Upto 300 m downstream from the proposed road bridge, necessary protection works are suggested on the sloping portion as well as on apron on the right side.



Details of Guide Bund for Proposed Road Bridge at Zadeshwar

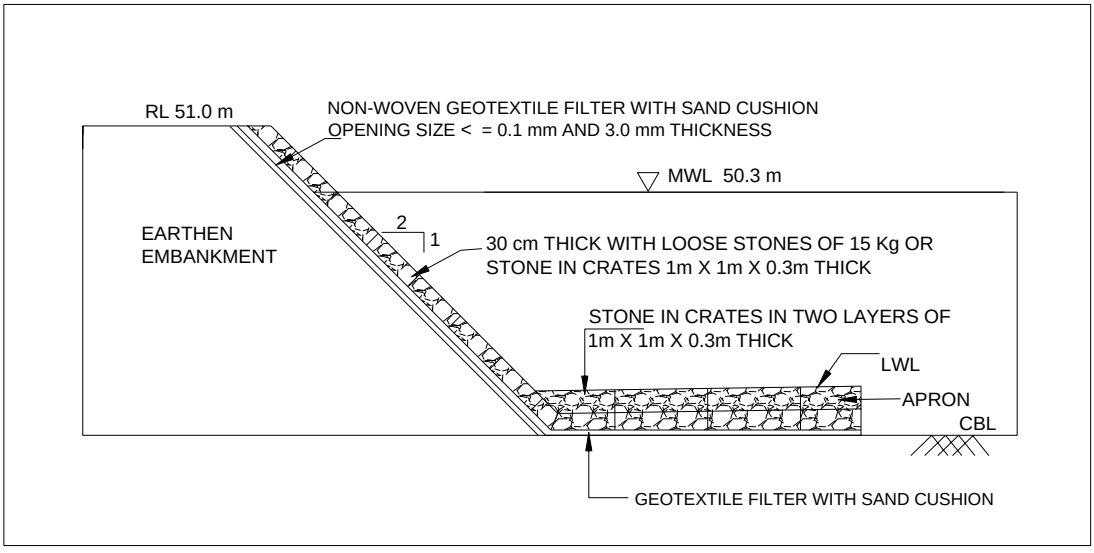
DERIVATION OF SHORE PROTECTION MEASURES FOR KAKRAPAR ATOMIC POWER PLANT UNITS 3 & 4, GUJARAT

Nuclear Power Corporation of India Limited (NPCIL) has proposed to expand Kakrapar Atomic Power Plant (KAPP) by constructing two units of 700 MW in Stage 3 & 4 between the existing units of KAPP Stage 1 & 2 and the Moticher Lake at Kakrapar, Gujarat. In order to protect the power plant of KAPP 3 & 4 from flood waters of Moticher Lake, shore protection scheme consisting of masonry retaining wall backed by an earthen embankment was proposed by NPCIL authorities. The design of the embankment with lake side slope of 1 (V) : 2 (H) and two alternative drainage systems, viz., graded filter and geotextile filter with sand cushion on both the sides was proposed by CWPRS based on soil properties estimated by laboratory testing and carrying out stability analysis. During the floods, high flow velocities were likely to be generated along the lake. Hence, design of slope protection with stone/gabion pitching was also provided to withstand the erosive action of flow, when the peak flood passes through the Moticher Lake. Moticher Lake carried out at CWPRS gave the peak inflow of 5806.4 m^3/s at Maximum Water Level (MWL) of RL. 50.3 m. Field measurements for velocity and depth were carried out in Moticher lake during September 2009. The maximum velocity observed was 0.15 m/s with lake level at RL. 46.70 m. The velocity of 2.2 m/s derived for design flood and lake level at RL. 50.3 m was used for design of the protection of the embankment on the lake side. Protection scheme consisting of slope pitching and apron with stone in crates over a layer of geotextile filter as detailed below were recommended.

Filter : Non woven geotextile filter having opening size O90 < 0.1 mm and Thickness > 3mm between 15 to 20 cm thick sand cushion.

Slope pitching : 30 cm thick loose stones of 15 kg weight or stones in crates of size 1.0 m x1.0 m x 0.3 m .

Apron : 6 m wide and 0.6 m thick apron with stone in crates of size 1.0 m x 1.0 m x 0.3 m in two layers.

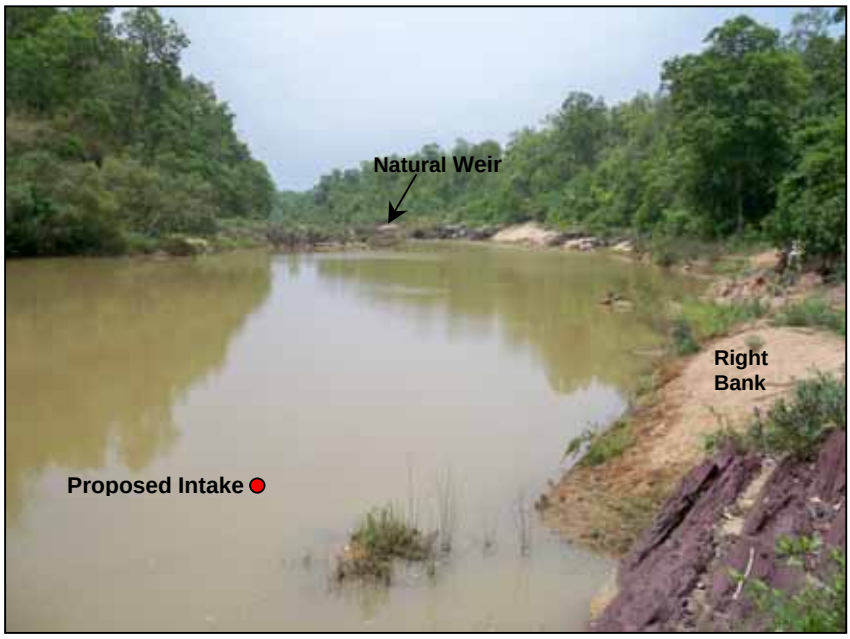


Typical Section of Embankment and Protection Works

LOCATION AND HYDRAULIC DESIGN OF INTAKE WELL IN RIVER SABRI FOR THE PROPOSED STEEL PLANT OF NMDC NEAR JAGDALPUR, CHATTISGARH

The Natural Mineral Development Corporation (NMDC) proposes to setup an integrated steel plant of 3.0 Million Ton Per Annum capacity at Nagarnar village near Jagdalpur town. Water requirement of about 53.69 Mm3 for the plant is proposed to be drawn from river Sabri through an Intake with pump-house. Water from the Intake will be pumped to the plant site for a distance of about 33 km. Studies were undertaken for deciding the location and hydraulic design of the Intake.

Location and hydraulic design of Intake were suggested on the basis of site inspection and analysis of survey, hydraulic and sediment data. During site inspection and also from the analysis of survey data, it was observed that due to presence of a rock outcrop, acting like a natural weir, a big pool of water with 3 to 4 m depth was available in its upstream at the proposed site. The Intake location was suggested at about 300 m upstream of the rocky outcrop. Intake in the deep channel with multi-level openings was found to be feasible for drawing comparatively silt free water from upper level during monsoon and from lower level during the lean season. Adequate capacity slurry pumps were also suggested for removal of sediments from the forebay and pump-sump. Bank protection, in the form of stones in crates over a suitable synthetic filter on the right bank for a reach of about 50 m upstream to 20 m downstream of the Intake was also recommended.



Proposed Intake Location in Deep Channel Upstream of Natural Weir

HYDRAULIC MODEL STUDIES FOR EVOLVING LONG TERM MEASURES AGAINST EROSION ALONG THE RIGHT BANK OF NUBRA RIVER IN LADAKH, J&K

Due to recurring erosion along the banks of river Nubra during floods every year, the Govt. of Jammu and Kashmir requested CWPRS to suggest short as well as long-term river training measures after 1985 flood. Short-term river training and bank protection works had been suggested by inspection of the affected sites by CWPRS officers from time to time. Project officers during their visit to CWPRS in February 2007 requested for hydraulic model studies to suggest long-term measures for protection to the right bank of Nubra River between Kuri and Charasa. They also expressed the need of having a number of bridges across Nubra River in the reach under study to provide connectivity to the habitation in the vicinity. Accordingly, a physical model was constructed to a horizontal scale of 1:180 and a vertical scale of 1:60 as per the river cross-section data of 2007 covering a river reach of 500 m upstream of Murgi to 500 m downstream of Charasa. Velocities, water levels and flow conditions were observed along the banks under existing conditions and with proposed road bridges in position for different river discharges from 375 m^3/s to 1200 m^3/s.

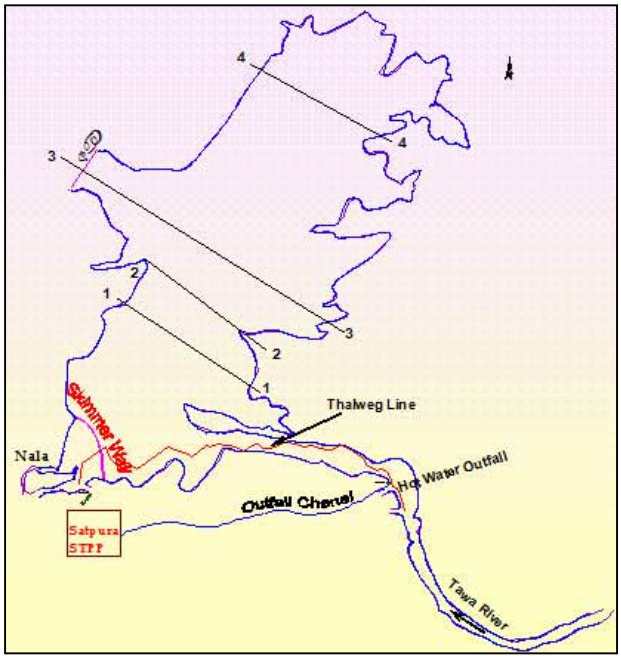
On the basis of the above observations on the model, bank protection works were suggested in the vulnerable reaches in the form of stones in crates over a suitable synthetic filter along with launching apron for the protection of toe of the affected bank. From the model studies, four locations were identified for the bridges with waterway of about 120 m. Construction of these bridges will hold the river at fixed location which will also help in channelizing the river course and thereby reducing erosion on the bank in the vicinity. Small channels leading towards the banks from main stream were suggested to be blocked with temporary structures like stone in crates to help channelizing the river course. Considering the average aggradations of about 18 cm per year in the river bed, it was suggested to provide sufficient free board at the bridges.

Physical Model Showing the Location of a Proposed Bridge

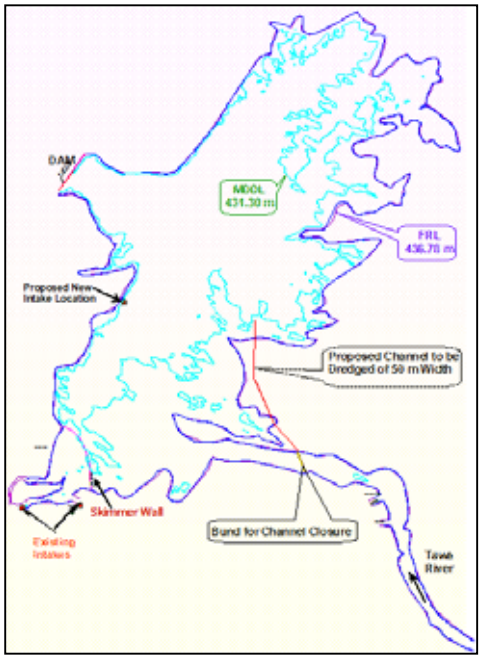
MEASURES FOR PREVENTION OF HOT WATER ENTRY AT THE INTAKE OF SATPURA TPS

The Satpura Thermal Power Station (TPS) at Sarani on the left bank of Tawa River in M. P. has total capacity of 1142.5 MW. The cooling water requirement of 46.4 m^3/s for the plant is met from a reservoir created by construction of a dam on Tawa River at Sarani. The hot water from the condensers is carried through an open channel and discharged back into the reservoir at a distance of about 4 km upstream of the intake. Based on physical model studies conducted at CWPRS in 1983, a 325 m long skimmer wall with 2.5 m wide opening at the bottom at a depth of 9 m below the full reservoir level was proposed to minimize hot water recirculation at the intakes.

The skimmer wall functioned well since its construction in 1987 till May 2008. However due to excessive siltation in the vicinity of the skimmer wall, the surface water temperature rose to as high as 40^0 C during the summer of 2008. The hydrographic survey data of Sarani reservoir of August 2008 was analyzed to find water depth available during lean season / at MDDL. From the surface water temperature data of one year (May 2008 to November 2009), variation in temperature across the reservoir area was examined. On the basis of these observations, as a short-term measure, it was suggested to divert hot water discharge in the deep portion of reservoir by dredging a 50 m wide channel for about 1500 m length. As a long-term measure, it was suggested to relocate the Intake near the left bank of reservoir towards Sarani dam at about 700 m to 800 m downstream from the skimmer wall, where bank is stable and relatively very steep as a long-term measure.



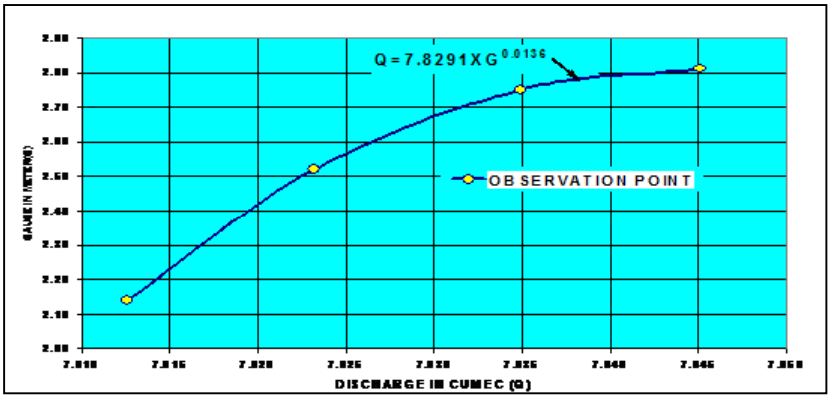
Plan Showing Location of Cross-Sections for Survey Data



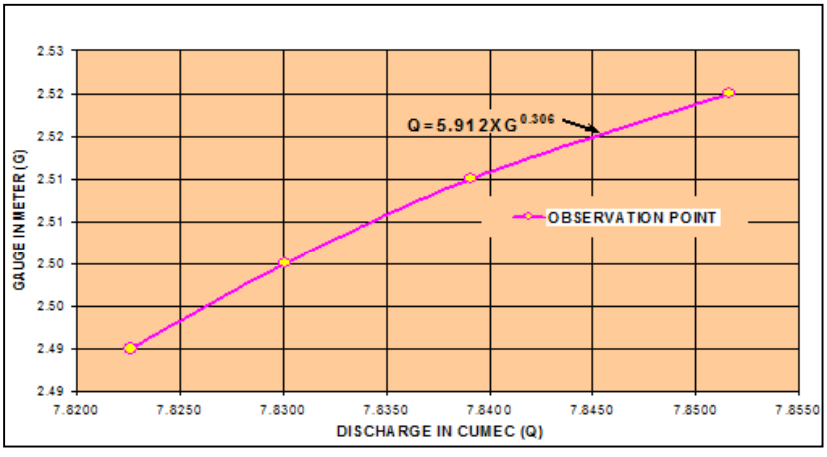
Proposed Pilot Channel Along Right Bank of Reservoir

FIELD STUDIES FOR RATING OF THE OFF-TAKE CANAL OF RIGHT BANK CHAMBAL CANAL AT ANTA GAS POWER STATION, RAJASTHAN

The Gas Power Project of M/s. NTPC Ltd at Anta, Rajasthan has an installed capacity of 419.33 MW. The water used for cooling purpose is taken from Right Main Canal of Chambal command area through 400 m long canal. The hot water from the condenser is discharged into the Kota Right Main Canal through a 360 m long discharge canal after passing through the condenser circulation. Field studies were conducted to estimate the quantity of water used by the plant for cooling purpose. Measurements were taken at one location each on intake and discharge canals for the entire range of operating discharges. The discharges were measured using 'Area Velocity Method' as described in IS 1192/1981. The flow section of the canals was divided into a number of small vertical segments. The average velocity of flow through each segment was obtained by measuring the velocity at depths of 0.2, 0.6 and 0.8 using a direct recording propeller type current meter manufactured by M/s Valeport Ltd., UK. The depth measurements were made using Echo-sounder having an accuracy of 0.01 m. Using the observed data, i.e. width of segment, depth and mean velocity of flow, discharge passing through each segment was first worked out. Adding discharges through all the segments, the total discharge in the canal was calculated. The difference between the measured discharges in inlet and discharge canal for a certain operating condition yields the quantity of the water consumed by the plant. The consumption of the water was estimated to be constant equal to 0.0935 m^3/s (3.30 cusec).



Gauae Discharae Curve at Inlet Canal



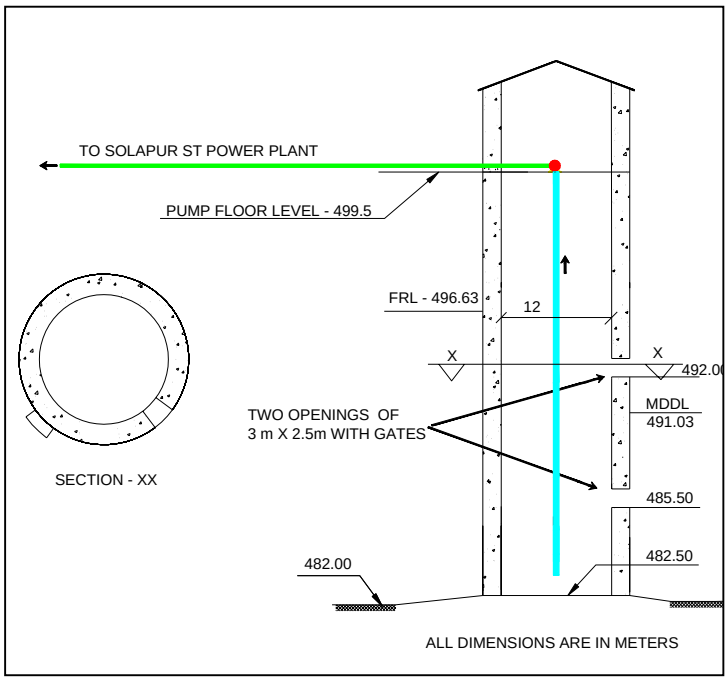
Gauae Discharae Curve at Discharae Canal

LOCATION AND TYPE OF INTAKE FOR PROPOSED SOLAPUR THERMAL POWER PLANT

A Thermal Power plant with a capacity of 2 x 660 MW is proposed to be constructed by M/s National Thermal Power Corporation (India) Limited at a distance of about 14 km from Solapur, Maharashtra. The plant water requirement of 1.7 m^3/s is to be drawn from Ujjani reservoir.

Studies were carried out to finalize the location of intake that would ensure perennial source of water to the plant and design the same. The data used for the study included Hydrographic survey data, plan and cross-sections of Ujjani reservoir, fortnightly inflow volumes to Ujjani Reservoir from 1981-82 to 2006-07 during monsoon and non-monsoon periods and elevation capacity curves of Ujjani Reservoir from 1977 to 2004.

Different locations for intake were reviewed considering the aspects like availability of water, length of approach bridge upto intake well, bed level of Ujjani reservoir at the end of the plant life, progressive reduction in storage capacity of Ujjani Reservoir and length of water supply pipeline upto plant site. The intake location near Ujjani reservoir upstream of existing intake for Solapur Municipal Corporation was finalized. Schematic of intake well structure for drawing water requirement was derived. Precautions to be taken to ensure uninterrupted water supply to plant site like desilting arrangements at intake well and at plant site as well as proper maintenance of gates were suggested.



Schematic of Intake Well

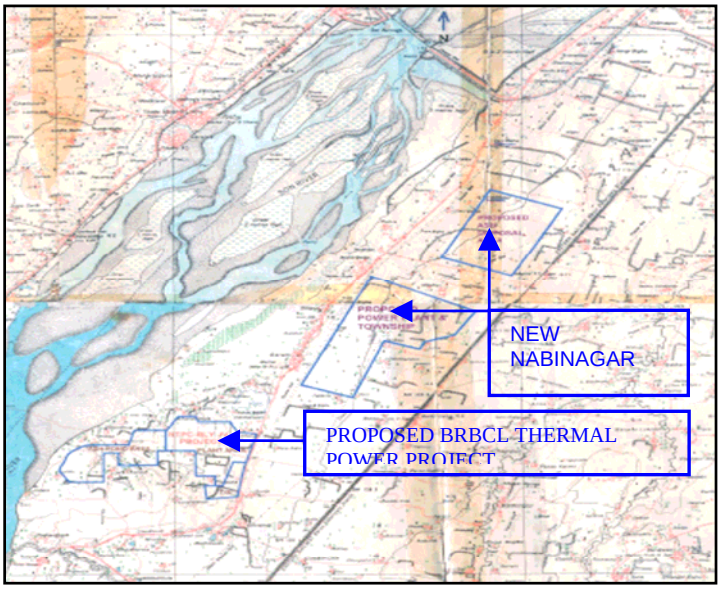
RIVER AND RESERVOIR SYSTEMS MODELLING

AREA DRAINAGE STUDIES FOR THE PROPOSED BRBCL THERMAL POWER PROJECT NEAR NABINAGAR, BIHAR

M/s Bihar Rajya Bijali Corporation Limited (BRBCL) is setting up a Thermal Power Plant of 4x250 MW on the right bank side of river Sone near Nabinagar, Bihar. Studies were carried out for deriving the storm water drainage system for the thermal power plant including ash dyke area and adjoining areas.

Data relating to topographic, hydrometeorological and high flood levels in river Sone were used for the studies. Analysis of daily rainfall data for a period of 42 years was carried out using Gumbel distribution. Based on the analysis, the 25, 50 and 100 year return period rainfall depths were estimated to be 155 mm, 174 mm and 193 mm respectively. The design of drainage is generally done for rainfall depth of 100 yr return period. However, in the present case only 25-yr return period value was adopted for design purposes at the insistence of NTPC. The value was further deduced considering the areal reduction factor as well as factor to obtain 2 hr rainfall depth from the daily value according to Central Water Commission (CWC) guidelines applied to the study area of 536 ha. Accordingly, the design rainfall depth was obtained as 71 mm.

Synthetic unit hydrograph for the study area was developed using CWC guidelines. Storm hydrograph corresponding to 71 mm rainfall depth was derived, considering a time of concentration of 2 hours. Components of runoff from the plant and ash dyke areas were added to the peak flow of storm hydrograph and design discharge for the drainage channels was derived. Outfall channel dimensions of storm water drains from plant and adjoining area to river Sone were derived in four segments having rectangular sections. The cross sections were designed considering masonry lining for sides and bed.

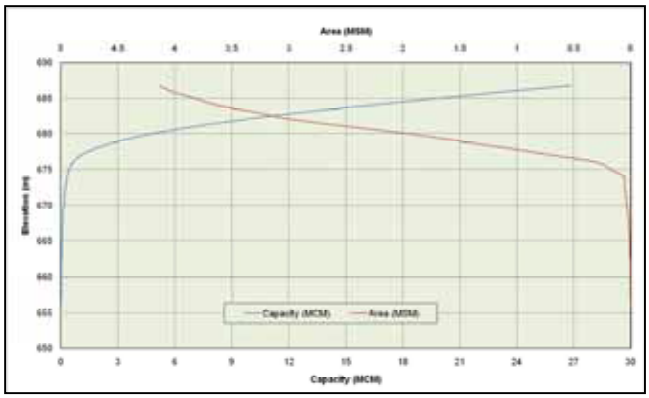


Location Map and Site-Plan of BRBCL Thermal Power Plant Area

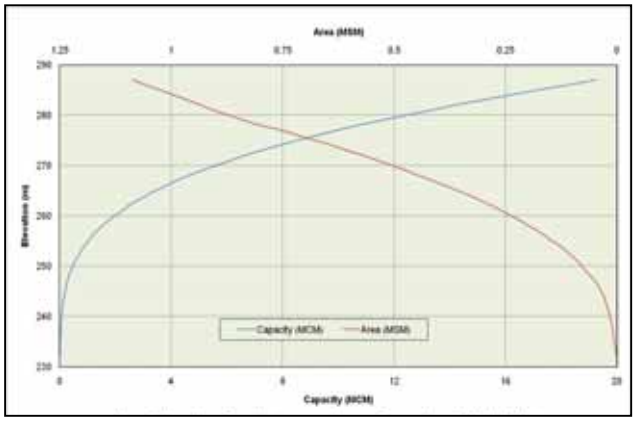
ESTIMATION OF SEDIMENTATION IN PROPOSED PUMPED STORAGE SCHEME AT MALSHEJ GHAT, MAHARASHTRA

Sedimentation analysis for the proposed upper and lower reservoirs of the pumped storage scheme planned at Malshej Ghat in Kalu river catchment were undertaken at the request of M/s Nuclear Power Corporation of India Ltd., Mumbai. The hydropower scheme is to have an installed capacity of 600 MW. The catchment area of the upper dam is 10.53 km^2; and that of the lower one is 26.03 km^2. The capacity of upper reservoir at FRL is estimated to be 26.85 Mm^3 and that of lower reservoir to be 19.25 Mm^3. As per the project appraisal report, the silt load is assumed to be 715 m^3/ km^2/year which give total silt volume for 100 year design life of reservoir as 0.752 Mm^3 for upper reservoir and 1.107 Mm^3 for lower reservoir having an independent catchment area of 15.50 km^2.

The analyses of topography and catchment characteristics of Malshej Ghat and also the study of various ideologies/ phenomena such as iso-erodent rate lines, annual loss of capacity, classification of sedimentation zones in India and actual capacity survey by Satellite Remote Sensing techniques by CWPRS indicated that the rate of sedimentation assumed in the project report for the upper and lower reservoirs of Malshej Ghat scheme are on the lower side. Based on the studies at CWPRS, it was recommended to adopt the total sediment volume through the catchment for 100-year life of reservoir for upper dam to be 1.582 Mm^3, and that for lower dam as 1.822 Mm^3. Accordingly, empirical area reduction method, suggested by Borland and Miller (1958), was used to estimate the distribution of sediment deposition in different zones for two nearby reservoirs.



Area-Elevation-Capacity Curve of Upper Reservoir

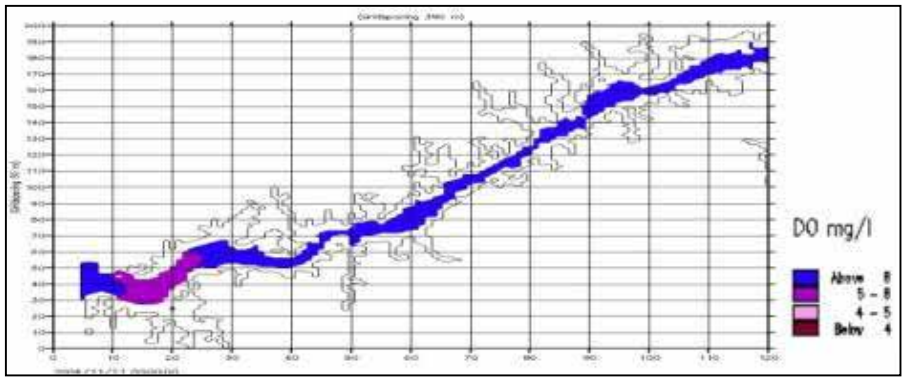


Area-Elevation-Capacity Curve of Lower Reservoir

SIMULATION STUDIES FOR ASSESSMENT OF WATER QUALITY OF SARDAR SAROVAR RESERVOIR, GUJARAT

Mathematical model study was conducted for assessing the Water Quality (WQ) in Sardar Sarovar reservoir as a result of the completion of the proposed upstream projects in the Narmada Basin. The present study was aimed at simulating the distribution of water quality parameters, like Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO), Nitrate (N) and Phosphorus (P) within the reservoir during normal flow year (2004-05), using water quality module of software MIKE 21. The water quality data collected during field investigations was used for calibration and verification of the model. The calibrated model was then used to simulate future scenarios with different qualities of effluents likely to join the reservoir. Major findings of the study are as follows:

- Water is suitable for all purposes, including drinking after disinfection with the existing scenario of pollution in the upstream area. The WQ of reservoir complies class 'A' criteria.
- Parametric analysis with different pollution loads of BOD = 700, 400, 200,100 and 30 mg/l discharged at the rate of 6 m^3/s indicated the maximum load of BOD that can be released without causing the deterioration in reservoir water quality is 100 mg/l. With this load, the WQ scenario in the reservoir portion at 1 to 5 km D/s to polluting points complied the class 'A' and 'B' criteria, meaning that the water can be used for all purposes, including drinking after disinfections.
- Within 200 m from one polluting point near the Gujarat-MP border, the quality of water was worse than class 'C' and 'D' criteria till first 5 days, meaning that the water is not suitable for drinking even after treatment and disinfection or for propagation of wild life and fisheries. The WQ scenario near the other two polluting points complied class 'A' and 'B' criteria. Time series analysis showed that for different pollution loads simulated, water quality parameters like BOD, DO, N and P reach a steady state within 25 days.
- As per the guidelines of CPCB/BIS, the maximum permissible load of BOD for disposal on land and in the surface water is 30 mg/l. When this load was simulated, WQ within 100m from that particular polluting point complied to class 'B', but not to class 'A'. The quality in that part of reservoir also improved eventually. In the vicinity of other two polluting points, the WQ complied class 'B' and 'A' also. Among the three locations studied, this location is not recommended for the discharge of pollution.

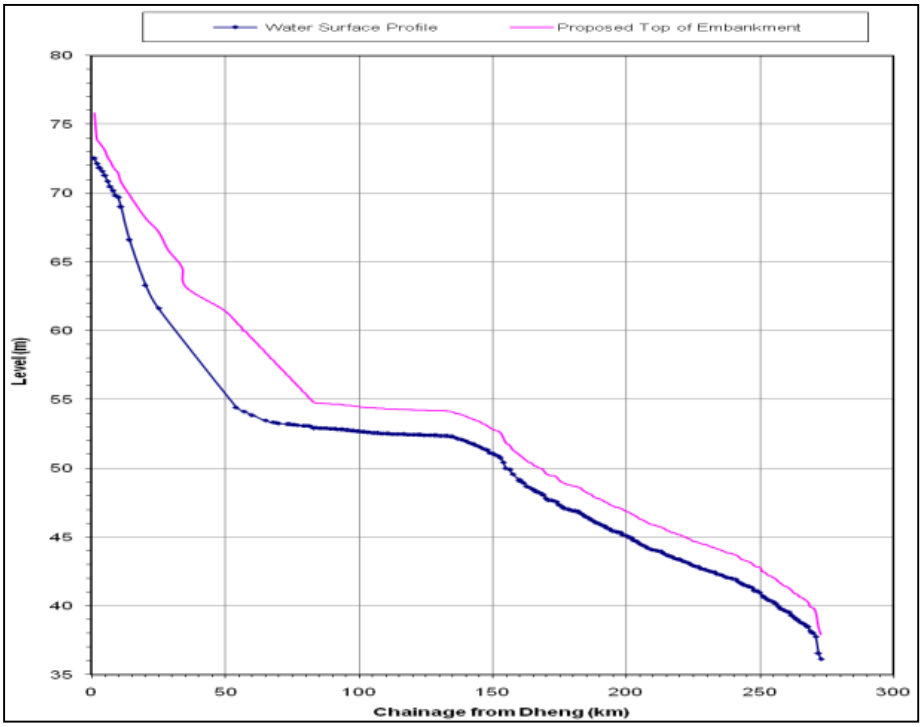


Spread Of DO After One Month With Pollution Input of 100 mg/l Discharged @ 6 m^3/s

MATHEMATICAL MODEL STUDIES FOR ESTIMATION OF HIGH FLOOD LEVELS IN BAGMATI RIVER, BIHAR

Bagmati River enters India in Sitamarhi district of Bihar and flows for 273 km upto its confluence with Kosi River. The river is known for meandering, braiding, changing course and frequent floods. Over the years, frequent floods have affected the villages in the vicinity of the banks. The Government of Bihar has proposed to construct embankments on both the banks of the river for protection of these villages. CWPRS carried out 1-D mathematical model studies for estimation of high flood levels to decide the top of embankment covering a reach of 273 km downstream of Dheng Bridge.

Water Resources Development, Bihar, made topographic and hydrologic data available, which were analyzed for continuity and consistency. It was understood that flows through breaches in the embankment contributed to the inconsistency in the data. Design discharge of 8245.7m^3/s was specified for upstream boundary. Normal flow conditions governed by Manning's equation were used for defining downstream boundary. The simulation was carried out with Manning's 'n' value of 0.030. Top of embankment was decided by adding a freeboard of 1.8 m to the HFL as per IS 12094:2000. Water levels for the entire reach of 273 km as obtained from the studies and the top levels of the embankment are presented in the figure below.



Water Surface Profile and Proposed Top of Embankment for Design Discharge - 8245.7 m^3/ s

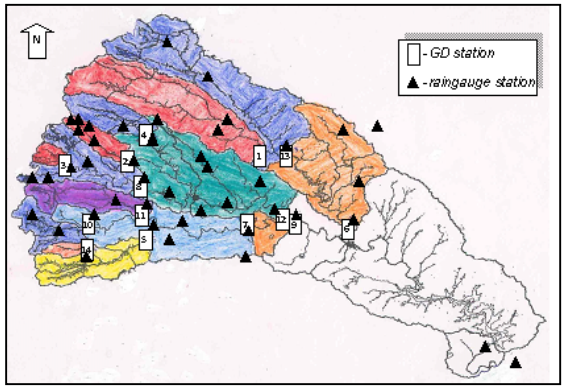
OPTIMIZATION OF STREAMGAUGE AND RAINGAUGE NETWORK FOR UPPER BHIMA BASIN

Optimization of stream gauge and rain gauge network in the Upper Bhima basin upto Ujjani reservoir was carried out by CWPRS jointly with the Water Resources Department (WRD), Government of Maharashtra under the provisions of Hydrology Project - Phase II. There is a stream gauge network of 14 Gauge-Discharge (GD) stations and a rain gauge network of 44 Ordinary Rain gauge Stations (ORG) in this pilot basin. The GD network of WRD, Maharashtra, evolved over a period of four decades has been providing inputs to water resources planning, with multi-objectives such as obtaining flow rates and volumes in major tributaries of Bhima and estimating water availability, peak flows, etc. at ungauged basins. Detailed review of existing stream gauge network was carried out as per World Meteorological Organization guidelines.

A model was developed for optimization of stream gauge network using spatial hydrologic regression under generalized least squares (GLS) framework and for ranking the stations according to their influence on measuring stream flows. It included large-scale processing of historical data collected at all GD stations in the basin. Cross-correlation among paired stations was analyzed for identifying redundancy in the existing network.

Network density of existing GD network in the basin was found to be 1050 km^2 per GD station, which agrees with the minimum density norms provided by WMO. Two GD stations at Pargaon and Chaskaman were classified as benchmark stations, wherein measurements continued for a longer period of time to provide general coverage of the region. Flows at four sites viz. Askheda, Chaskaman, Dattawadi and Wegre were affected due to construction of structures upstream. It was proposed to shift these sites and the requisite discharge data are to be measured at spillways of the upstream dams, viz. Bhama-Askheda, Chaskaman, Khadakwasala and Temghar. Based on the outcome of the statistical methods and empirical rules, it was concluded that data collection at two GD stations viz. Rakshewadi and Shirur be terminated. Thus, the suggested final optimum network consisted of twelve GD stations, with a network density of 1226 km^2 per GD station.

It was found that the existing rain gauge stations are unevenly distributed over the Upper Bhima basin and are also uneven with respect to the catchment area of stream gauge stations. The rain gauge network was assessed using spatial-correlation analysis approach and was evaluated in conjunction with the stream gauge network. It was found that 35 rain gauge stations would be optimum for estimation of areal rainfall for monsoon months with 5% error admissibility in estimation. For simultaneously taking care of two objectives of estimating areal rainfall over the entire basin and for the requirement of the existing GD stations, 42 rain gauges would be needed.



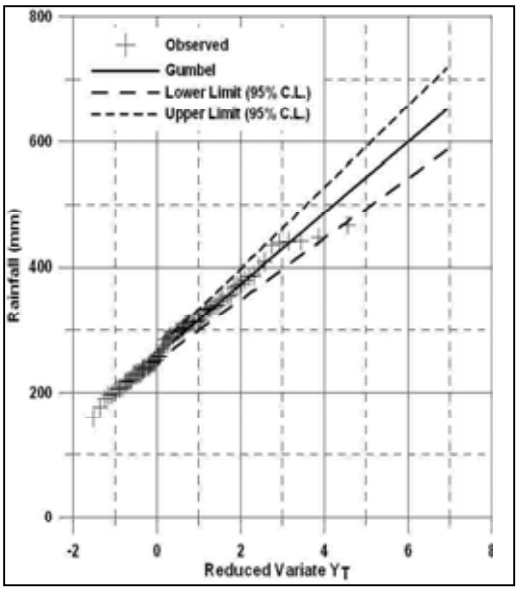
Hydrometeorological Network in the Upper Bhima Basin

EXTREME VALUE ANALYSIS OF RAINFALL DATA FOR BHIVPURI GHAT, MAHARASHTRA

The East West Gas Pipe Line (EWPL) from Kakinada in Andhra Pradesh to Bharuch in Gujarat of M/s Reliance Gas Transportation Infrastructure Ltd. (RGTIL) passes through Bhivpuri Ghat near Karjat, Maharashtra. The pipeline, buried at about 1.5 m to 2.0 m below ground, got exposed and damaged during heavy rains in 2008 in the Ghat area near village Khandi in Mavel Taluka of Pune District. In order to take adequate protective measures, CWPRS assessed the flooding and run off potential in the Bhivpuri Ghat region.

Accordingly, recorded daily rainfall data from IMD of three rain gauge stations in the neighborhood of the study area, viz. Matheran (1901- 97), Karjat (1901-2004) and Bhivpuri (1980- 2008), were analyzed to estimate the maximum 1-day rainfall for different return periods. For 50 year return period, 1-day extreme rainfall estimated for Matheran, Karjat and Bhivpuri Ghat rain gauge stations were 480.52 mm, 357.30 mm and 215.47 mm respectively. For 100 year return period, 1-day extreme rainfall estimated were 520.09 mm, 388.20 mm and 235.76 mm respectively. Considering reliability of the data, statistical test results, length of data and location and elevation criteria with reference to study area, 1-day extreme value estimated for Matheran is adopted as applicable rainfall for the study area.

The drainage area in the Bhivpuri Ghat region along the pipeline where soil erosion occurred in 2008 lies between the contour intervals 715 m and 395 m above MSL. The time of concentration for storm run off to flow through the drainage area was estimated to be about 5 minutes. Using the guidelines given by Central Water Commission and Indian Road Congress, intensity of rainfall for 5 minutes duration was estimated to be 284.76 mm/hr and 308.1 mm/hr respectively for 50 and 100 year return periods. The corresponding peak discharges for the study area were estimated using Rational Formula as 4.88 m^3/s and 5.28 m^3/s respectively. The results of the study enabled M/s RGTIL in reviewing the safety measures needed for EWPL in Bhivpuri Ghat region.



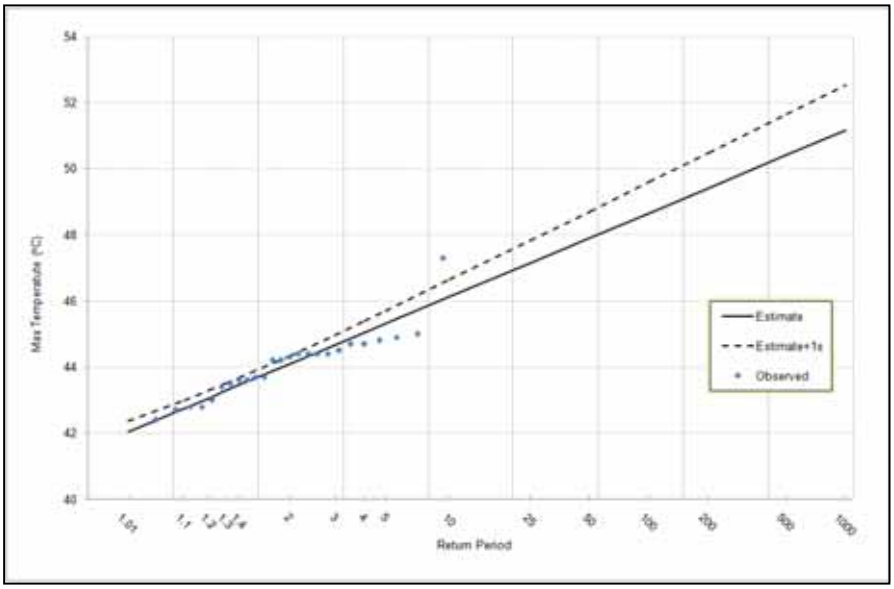
Estimated 1-Day Rainfall at Matheran Using Gumbel Probability Distribution

EXTREME VALUE ANALYSIS OF METEOROLOGICAL PARAMETERS FOR GUJARAT NUCLEAR POWER PARK AT JASPARA

Nuclear Power Corporation of India Ltd (NPCIL) proposes to set up a 6 x 1000 MW Nuclear Power Plant (NPP) at Jaspara in the Bhavnagar district, Gujarat. Extreme Value Analysis (EVA) of the meteorological parameters of the region around at Jaspara was carried out for planning and designing of the project. The data observed at the IMD observatory, at Bhavnagar, located at a distance of about 30 km from the project site, was used for the analysis.

Fisher Tippet Type I distribution, generally known as Gumbel distribution, and Fisher Tippet Type II, known as Frechet distribution, are identified as standard distributions for EVA for NPPs as per AERB Guidelines. Hence, EVA was carried out using statistical frequency analysis based on these two distributions. The probability distributions using Lieblein Technique based on order statistics was used for estimating expected values of extreme events for different return periods at different confidence limits. Adequacy of the fitted models was assessed by using Kolmogorov-Smirnov goodness of fit test and probability plots.

Based on EVA of the recorded rainfall data at Bhavnagar, the 1000-year design storms for 1-day, 2-day and 3-day were estimated to be 669 mm, 822 mm and 893 mm, respectively. The corresponding 84.13% upper confidence limits for the estimates of 1000-year design storms were 776 mm, 953 mm and 1036 mm, respectively. The 1000-year return period maximum temperature was estimated to be 51.2^{0}C and the corresponding 84.13 % upper confidence limit was 52.5^{0}C. The 1000-year return period minimum temperature was estimated to be -0.7^{0}C and the corresponding 84.13% lower confidence limit was -2.7^{0}C.



Observed and Estimated Maximum Temperature at Bhavnagar using Frechet (3P) Distribution

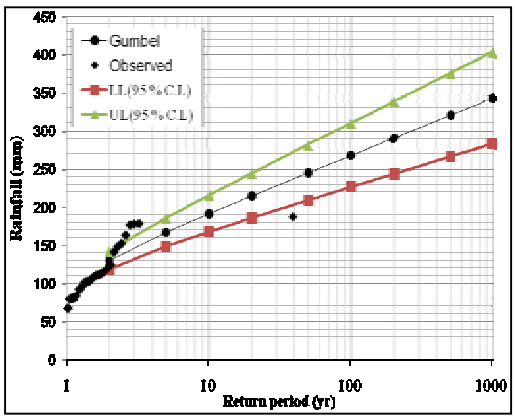
EXTREME VALUE ANALYSIS OF METEOROLOGICAL PARAMETERS FOR CHUTKA NUCLEAR POWER PROJECT SITE, MADHYA PRADESH

The Nuclear Power Corporation of India Ltd (NPCIL) proposes to set up a 2x700 MW Nuclear Power Plant (NPP) at Chutka in the upper Narmada river basin in Mandla district of Madhya Pradesh (MP). Extreme Value Analysis (EVA) of hydrometeorological data was carried out to adopt protective measures against any natural vulnerability in the planning stage of the project. Data recorded at the nearest India Meteorological Department (IMD) stations at Jabalpur and Mandla were used for the analysis. Data validation tests for independence, homogeneity and outliers were carried out to check the quality of available data.

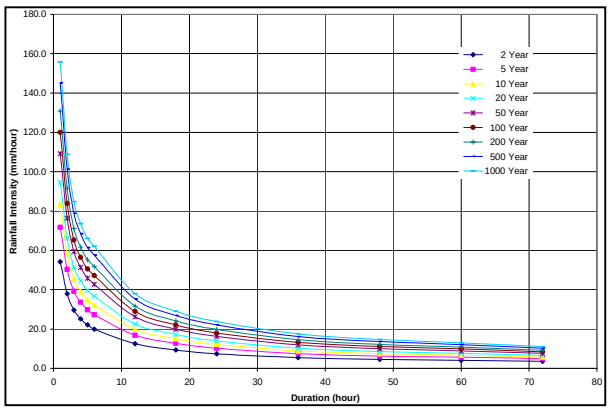
As per Atomic Energy Regulatory Board (AERB) guidelines, Gumbel and Frechet distributions were used for obtaining extreme estimates of the hydrometeorological data for 1000 year return period as shown in the following table.

Station	Parameter	Gumbel Distribution		Frechet Distribution	
		Mean Estimate	84.13 % upper Confid. Limit	Mean Estimate	84.13 % upper Confid. Limit
Jabalpur	24 hr. design storm (mm)	572.3	650.1	1767.5	2841.1
	48 hr. design storm (mm)	707.6	804.4	2247.6	3643.1
	72 hr. design storm (mm)	797.6	903.8	2066.4	3177.1
Mandla	24 hr. design storm (mm)	367.4	415.5	798.6	1163.3
	48 hr. design storm (mm)	510.0	580.2	1312.2	2023.0
	72 hr. design storm (mm)	643.5	735.7	1830.3	2939.4
	Max. Temp (^{0}C)	52.6	54.0	53.5	55.2

The 24-hr mean estimates for 1000-yr return period obtained using Gumbel distribution for the region varies from 367.4 mm to 572.3 mm; and the estimates with an upper confidence level of 84.13 % varies from 415.5 mm to 650.1 mm, which are comparable with 1-day PMP for Chutka region obtained the from the PMP atlas prepared by IITM, Pune. The extreme rainfall estimates obtained using Frechet distribution is noted to be always on the higher side, as this distribution uses log transformed data series. Hence, estimates obtained using Gumbel extreme value distribution is found to be reasonable. Intensity-Duration-Frequency (IDF) curves were also obtained for Jabalpur and Mandla sites to define the intensity of rainfall for different durations with associated recurrence periods.



Estimated 1-Day Extreme Rainfall for Mandla Using Gumbel Distribution



IDF Curve for Jabalpur Using Gumbel Distribution

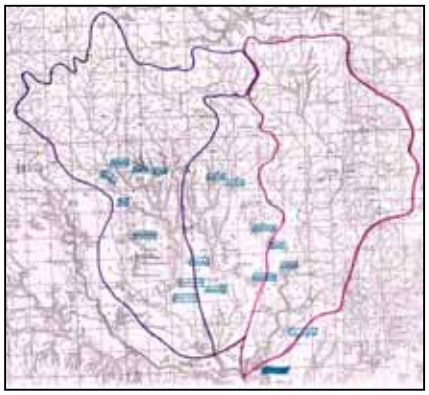
FLOOD ROUTING STUDIES FOR PAKRI BARWADIH COAL MINE AREA, JHARKHAND

M/s National Thermal Power Corporation (NTPC) has taken up coal mining operation in the state of Jharkhand near Pakrii Barwadih and Chattibarittu villages to ensure continuous supply of coal to their thermal power plants spread all over the country. The coal mine block is spread over an area of 4626 ha. There are three nallas, viz. western nalla (Khora), central nalla (Dumuhani) and eastern nalla (Pakwa) originating on hill slopes towards the northern boundaries. As the central nalla is obstructing the mining operations, it is necessary to divert the flows to the adjoining eastern and western nalla. CWPRS carried out the following studies for this purpose:

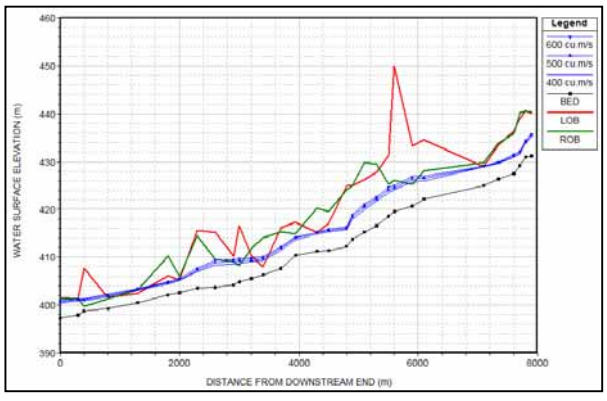
- Estimate flood discharge of nallas in Pakri Barwadih coal mining block
- Review the drainage pattern in line with coal extraction plan
- Propose diversion of nalla affecting the mining operations.

As there were neither gauging sites nor rain gauges in the study area, the design discharge from the catchment area of each nalla was estimated using synthetic hydrograph as per CWC norms. Maximum discharge for the eastern and western nallas after considering the diverted discharges from the central nalla and the pumping discharges from the coal pits, over and above the discharge from own catchment works out to 521 m^3/s and 500 m^3/s for Khora and Pakwa nallas respectively. Flood routing studies were conducted to get the high flood levels in each nalla. From this it was noticed that raising of banks for Khora nalla by 3.5 m would be required between 0.3 to 0.6 km and 2.75 to 4.5 km. The same would be needed between 0.3 to 2 km on Pakwa nala. The diversion discharges from the central nala to eastern and western nala are 60 and 8 m^3/s respectively. The diversion channels were designed accordingly with a slope of 1 in 500 and the appropriate alignment was also suggested. Six check dams on each nalla to store the water requirements of coal mining are proposed. Storage capacity of the check dams was reviewed and a deficit of 0.05 Mm3 was found as against the requirement of 1.67 Mm^3.

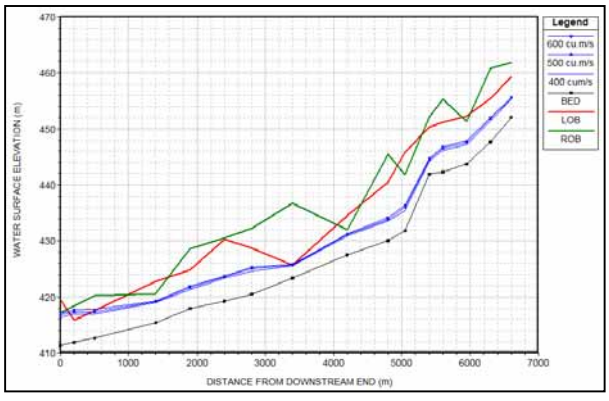
Pakri Barwadih Coal Mining Block, Jharkhand



Map of Catchment Area



Water Surface Profile for Pakwa Nalla



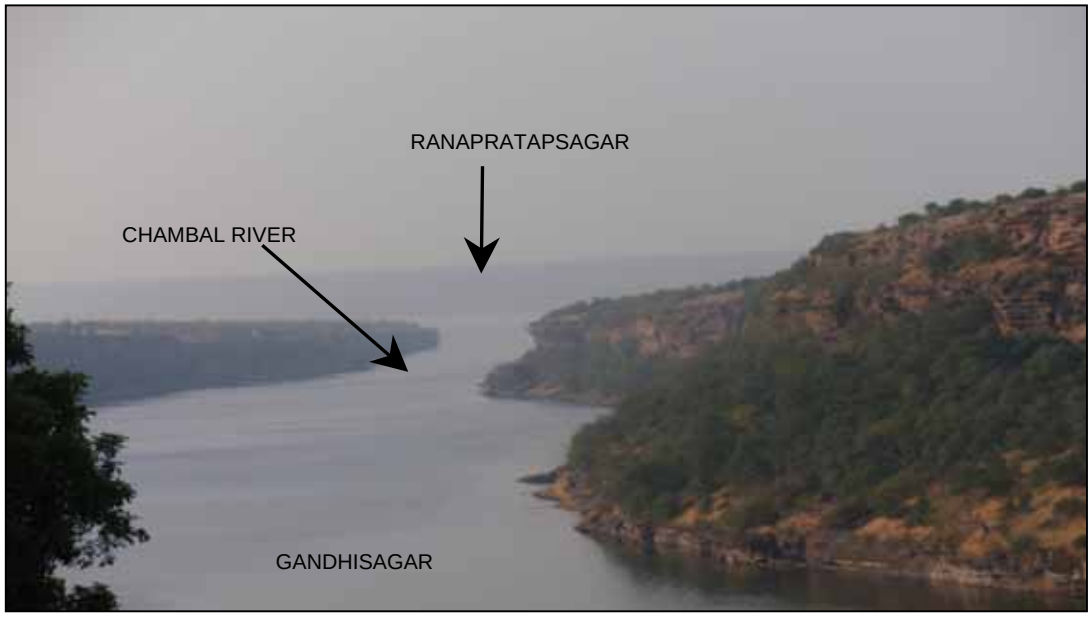
Water Surface Profile for Khora Nalla

ASSESSMENT OF GRADE LEVEL OF PROPOSED RAJASTHAN ATOMIC POWER PLANT UNITS 7 & 8

Rajasthan Atomic Power Plant (RAPP) is located on right bank of river Chambal between Gandhi Sagar and Rana Pratap Sagar reservoirs. It is proposed to add two more units of 700 MW each in Stage 7 and 8. The proposed grade level of these units is 408 m which is 4.44 m above the top of Gandhi Sagar dam upstream. As per the requirements of AERB, studies were carried out to estimate maximum water level sequel to breach of Gandhi Sagar dam along with the passage of PMF from Gandhi Sagar to Rana Pratap Sagar dam.

Hydraulic data in respect of inflow hydrograph to Gandhi Sagar dam and the hydrograph of intervening catchment between Gandhi Sagar and Rana Pratap Sagar dams were supplied by NPCIL. The geometry of reservoirs was represented using elevation-area-capacity curve collected jointly by CWPRS and NPCIL and channel of river Chambal between two reservoirs was defined using topographic survey data used in CWC Report of 1999. The Manning's roughness coefficient 'n = 0.033' for routing the flows in Chambal river was taken as per the CWC Report.

First, both the estimated dam break flood hydrograph and PMF hydrograph were routed through Gandhi Sagar reservoir. The outflow from reservoir was next transferred to the Chambal river reach from Gandhi Sagar to upstream end of Rana Pratap Sagar reservoir. The channel outflow hydrograph was finally routed through Rana Pratap Sagar assuming that Rana Pratap Sagar dam would not fail during the passage of both the floods. The maximum water levels in Rana Pratap Sagar thus derived indicated a minimum free board of 41.44 m with respect to grade level of 408 m will be is available, which is considered to be adequate.



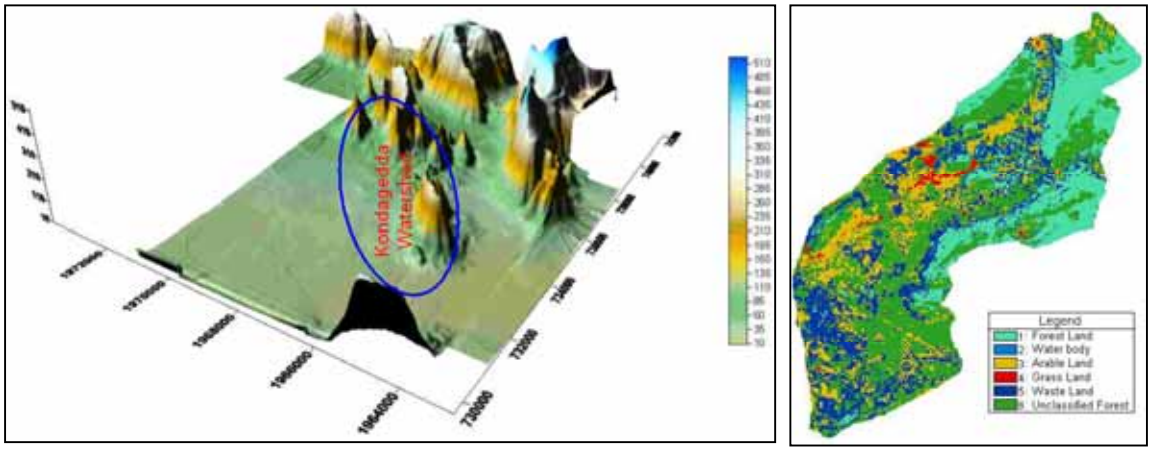
Chambal River Reach from Gandhi Sagar to Rana Pratap Sagar

ESTIMATION OF SEDIMENT YIELD FOR KONDAGEDDA NEAR NAVAL PORT AND DOCKYARD, VISAKHAPATNAM

The Indian Navy has an Airport at Visakhapatnam. Two major streams Mehadrigedda and Kondagedda drain water at the NW corner of the Airport and the streams run round the airport before reaching the naval basin and draining into the sea. The airport being in low lying area is prone to inundation during severe storms. Following inundation of the airport in 1997 and 2005, the Irrigation and Command Area Development Department, AP, got the channelization studies done for the region. It was apprehended that channelisation of Kondagedda and Mehadrigedda around the airport would result in siltation of Mehadrigedda. CWPRS conducted the studies relating to sediment yield estimation for Kondagedda.

Soil samples at typical locations from Kondagedda catchment and river bed were collected. Rainfall data (monthly and hourly) were collected from Indian Meteorological Department from which mean annual precipitation and rainfall index were estimated. Land use classification was done using remotely sensed data and a Digital Elevation Model (DEM) of Kondagedda was developed using Survey of India toposheets. As Kondagedda and Mehadrigedda rivers are ungauged, DEM was used to estimate factors like catchment area, slope-length and drainage density.

Soil erosion and sediment yield models such as USLE, Garde's method and Musgrave equation were used to estimate the sediment yield for Kondagedda. Sediment yield of Kondagedda watershed up to National Highway NH5 was 82.16 t/ ha/ yr. Physically based KINEROS2 model was also applied in the studies, which gave sediment yield as 89.15 t/ ha/ yr. The results of the study are being used for siltation studies of the streams near the Airport.



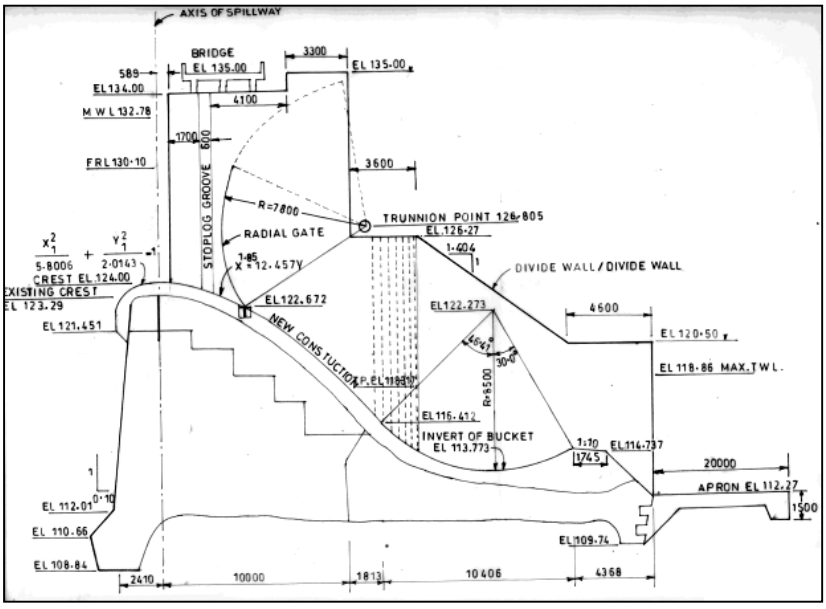
DEM of the Region Around Project Area and Land Use Map of Kondagedda Watershed

RESERVOIR AND APPURTENANT STRUCTURES

HYDRAULIC MODEL STUDIES FOR UMTRU DAM SPILLWAY, MEGHALAYA

The existing 4 x 2.8 MW Umtru HE Project with an un-gated spillway of length 106.71 m is proposed to be upgraded to produce 2 X 20 MW of power by optimally utilizing the continuous spillage of river flows over the existing spillway. The proposed modification includes providing an ogee profile with the crest at EL 124 m, and a ski-jump type energy dissipater over the existing spillway structure. The modified spillway will have 6 bays of 14.3 m width, along with the radial gates of height 7.728 m supported on piers of 3 m width. It is designed to have same MWL (EL 132.8 m), FRL (EL 130.1 m); and will be accommodated in the existing spillway width to pass a Standard Project Flood of 2,400 m^3/ s and a Probable Maximum Flood of 3,500 m^3/ s.

A 2-D sectional model of Umtru dam spillway was constructed to a geometrically similar scale of 1:30 in a glass sided flume, reproducing one full and two adjacent part bays along with two piers and radial gates. The studies indicated that the discharging capacity of the spillway was adequate. However, the flow conditions over the spillway were not satisfactory as the flow separated out form the piers, forming a cavity along the piers, for discharges above1,750 m^3/s. To improve the flow condition, it was recommended to shift piers to start from the upstream face of the spillway. The performance of the ski jump bucket was unsatisfactory for discharges higher than 1,750 m^3/ s as the clear ski action was not seen due to unsatisfactory approach flow, inadequate bucket radius and excessive tail water level. On the basis of the studies, it was recommended to increase the bucket radius to 9.5 m and exit angle to 35°; which will be studied further on the model to arrive at hydraulically acceptable design.



Cross Section of Umtru Dam Spillway

Flow Condition for Discharge of 3,500 m^3/s

HYDRAULIC MODEL STUDIES FOR TAIL RACE SYSTEM OF CHHUKHA HE PROJECT, BHUTAN

Chhukha HE Project is a run-of-the-river scheme on river Wangchu in Bhutan, with an underground power house equipped with four vertical shaft pelton turbines of 84 MW each, utilizing a total discharge of 95,167 m^3/ s for design head of 435 m. The tail race system consists of four unit Tail Race Tunnels (TRTs), collection chamber and a 990 m long D-shaped main TRT which is 990 m long of size 7 m x 4.5 m.

During its operation prior to 1997, it was observed that only 320 MW of power could be generated, against the installed capacity of 336 MW. Hence, an additional D-shaped TRT of length 990 m and size 3 m x 4 m was constructed in front of the Unit TRT IV for carrying its discharge directly to river. With this, the project could generate maximum power up to 360 MW, with 10 % overload during high inflow season as against the maximum power of 369.6 MW. Any attempt to generate power beyond 360 MW was leading to heavy oscillation on the active power meter of Unit III and splashing of water above the grill of Unit TRT III. In view of this, Hydraulic model studies were conducted on a 1:25 scale comprehensive model to assess the flow conditions in the four unit TRTs, collection chamber and in both the TRTs up to the exit portal.

The studies conducted on the original layout indicated the abrupt change of direction in the alignment of Unit TRTs I, II & III with the collection chamber and inlet of the additional TRT was causing piling up of flow in the collection chamber and Unit TRT III. In order to reduce the water level in the collection chamber and pump house area, smoothened junctions of Unit TRTs I, II & III with collection chamber and inlet of additional TRT was incorporated in the model. This was effective in reducing the depth of flow in Unit TRT III by 0.5 m and in the pump house area by 0.2 m for the condition of units generating 369.6 MW. With this reduction in water depths, it is felt that the splashing of water in Unit TRT III, would be mitigated and it would be possible to achieve the maximum generation of 369.6 MW.

Flow at the Junction of Unit TRT I and Collection Chamber for the Condition of All Units Operational for the Original Design

HYDRAULIC MODEL STUDIES FOR MODIFIED DESIGN OF SPILLWAY AND POWER INTAKE OF KOTLIBHEL HE PROJECT, STAGE I B, UTTARAKHAND

Kotlibhel HE Project – Stage I B is a run-of-the river scheme on river Alakananda in Tehri Garhwal District of Uttarakhand. The project envisages construction of a 90 m high concrete gravity dam with spillway consisting of six spans each with an opening of size 15 m (W) x 21.2 m (H) with breast wall and has been designed to pass the design discharge of 26,615 m^3/s at MWL EL 522 m. The energy dissipater is provided in the form of stilling basin with modified bed level at EL 455.8 m. A surface powerhouse on the right bank has been provided with an installed capacity of 320 MW (4 x 80 MW).

Hydraulic model studies were conducted at CWPRS earlier on 1:80 scale comprehensive models for spillway and power intake for the original design. Based on the results of these studies, several modifications such as dressing of ground/sides upto specified contour levels on upstream and downstream, lowering of stilling basin by 5 m and recessing the power intake by 5.5 m were suggested. These modifications were incorporated in the model and tested to assess the conditions upstream and downstream of spillway, discharging capacity of the spillway with partial gate operation, and performance of the stilling basin with apron at EL 455.8 m. The studies indicated that the flow conditions upstream of spillway were uniform for the entire range of discharge and reservoir water levels for partial gate operation. Discharging capacity for partial and equal operation of all six gates with opening ranging from 2 m to 20 m for various water level upto FRL EL 521 m was assessed. The flow conditions in the vicinity of power intake were mild and the vortices reduced when both the intake and spillway operated simultaneously.

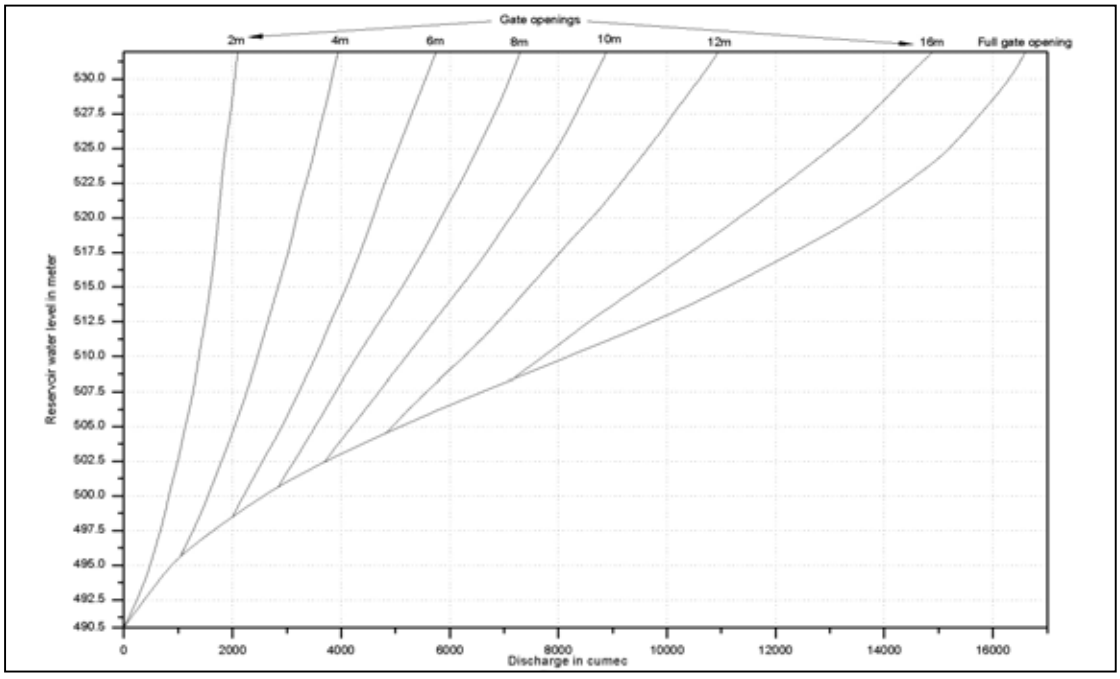
Hydraulic jump formed in the stilling basin for the entire range of discharges for gated and ungated operation of spillway and so the performance of stilling basin was satisfactory. The cellular wall between the spillway, stilling basin and tailrace channel was not getting overtopped. Flow conditions in the tail race channel were mild when spillway was closed.

Performance of Stilling Basin for Un-Gated Operation of spillway for Q=26615 $m^{3/}$ s

ASSESSMENT OF DISCHARGING CAPACITY OF REVISED DESIGN OF SPILLWAY OF KOTLIBHEL HE PROJECT –STAGE I A, UTTARAKHAND

Kotlibhel HE Project –Stage I A, is a run-of-the-river scheme on the Bhagirathi River in Tehri Garhwal district of Uttarakhand. It is located about 3.8 km upstream of confluence of rivers Bhagirathi and Alakananda at Devprayag. The project envisages construction of an 82.5 m high and 129 m long concrete gravity dam. The breast wall spillway consists of 5 spans of dimensions 11.0 m (W) x 18.5 m (H) and has been designed to pass the Probable Maximum Flood (PMF) of 13600 m^3/s at FRL EL 532 m. The energy dissipator is provided in the form of ski-jump bucket followed by a 15 m wide apron. A 40 m wide plunge pool is provided 46 m downstream of the bucket lip with bed at EL 450 m. An underground powerhouse provided on the left bank has an installed capacity of 196 MW under a water head of 63.33m.

Hydraulic model studies for the spillway and energy dissipator were conducted for the original profile on a 1:70 scale comprehensive model to assess discharging capacity and flow conditions upstream and downstream of spillway. Taking due cognizance of the results, the spillway crest was lowered by 9 m spillway profile was changed to $x^2 = 166$ y and ski-jump bucket lip was raised by 8.215 m. With these modifications, it was observed that the PMF of 13500 m^3/s could be passed with all 5 spans fully open and also with one gate inoperative. As such, it was felt that the span width could be reduced from 11 m to 10.3 m. The model studies with the revised spillway span indicated that the PMF of 13500 m^3/s could be passed through all 5 spans and with one span inoperative. Hence the discharging capacity of the spillway was found to be adequate. Flow conditions over the spillway and energy dissipator were satisfactory for the entire range of discharges for the reduced span width of 10.3 m. Studies were also conducted to assess discharging capacity of the spillway with partial opening of the radial gates ranging from 2 m to 16 m for various reservoir levels upto FRL EL 532 m.



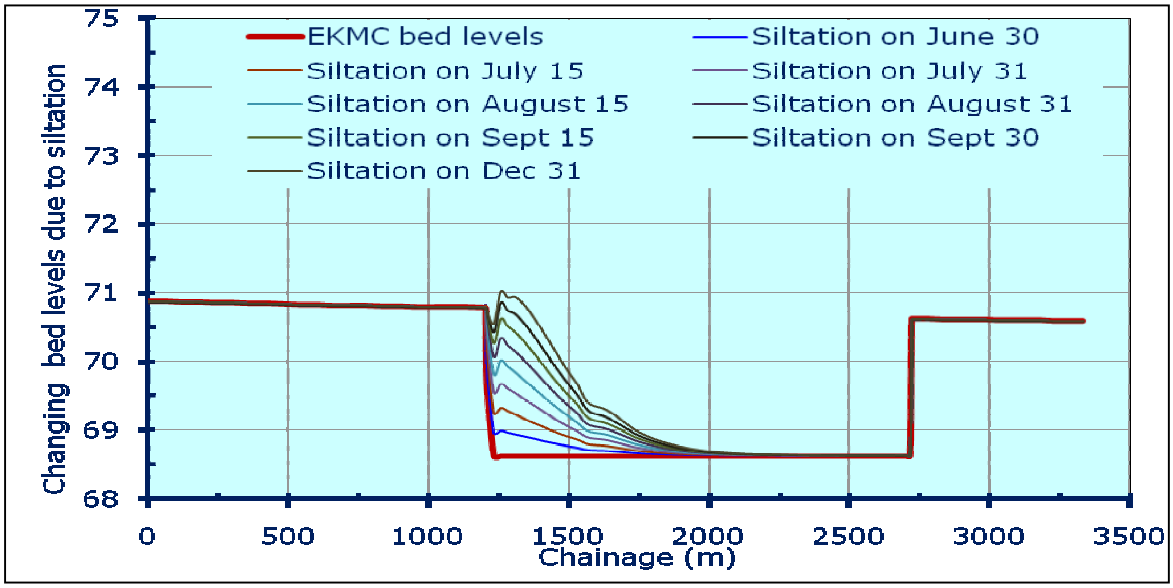
Discharging Capacity Curve for Partial and Full Gate Operation

PERFORMANCE EVALUATION OF SETTLING BASIN ON EASTERN KOSI MAIN CANAL, BIHAR

Water Resources Department (WRD), Bihar, is envisaging construction of a settling basin on Eastern Kosi Main Canal (EKMC), which takes off from the River Kosi at Bhimnagar barrage. The water diverted from heavily silt laden River Kosi also brings large quantity of silt into the EKMC. The silt carrying capacity of EKMC is inadequate, thereby causing huge siltation on the bed of channel, which needs expensive regular removal of silt. The proposed settling basin at EKMC has a total length of 1517.875 m and will have a gradual expansion transition at the rate of 1:4 for a length of 364.5 m till maximum bed width of 292 m is reached and this width is continued for subsequent 880 m length. The width then converges at the rate of 1:3 for the length of 373.375 m so that the canal regains its original cross section. The bed level at the start of settling basin is 70.78 m and it is lowered by 2.16 m to 68.62 m within a distance of 6.48 m at the start of expansion transition. The Mathematical model studies were carried out by CWPRS for assessing the adequacy of various geometrical parameters of settling basin on EKMC for trapping silt using HECRAS software.

Simulation studies were carried out using suspended sediment and discharge data provided by WRD, Bihar, as upstream boundary condition. The model simulation covered 3.2 km reach of EKMC and was carried out for two periods i.e. June to October with average discharge value of 342 m^3/ s and suspended silt load of 2.2 gm/ l and November to May with average discharge value of 118 m^3/ s and suspended silt load of 0.25 gm/ l.

The flow velocity profiles and bed siltation profiles over the settling basin were derived for the above two cases of simulation. Majority of siltation was observed in the first half portion of the settling basin. The converging portion of settling basin experienced accelerated velocities, therefore there was no siltation in that zone and the efficiency of settling basin to trap the sediment was of the order of 90 %. The design parameters were found adequate for capturing the desired quantity of silt thereby ensuring silt free water for irrigation and power generation.



Siltation Pattern in Settling Basin at Different Times

HYDRAULIC MODEL STUDIES FOR ASSESSING THE PERFORMANCE OF PARE DAM SPILLWAY, ARUNACHAL PRADESH

The Pare HE Project is planned as a run-of-the river scheme on the Dikrong / Pare River in Papumpare district of Arunachal Pradesh. The project envisages construction of a 78 m high concrete gravity diversion dam, about 3 km long water conductor system and a surface power house with an installed capacity of 110 MW. The breast wall spillway has been provided to pass the flood as well as to flush the sediment deposited in the reservoir into the river downstream. The spillway is designed to pass the maximum design outflow flood through 3 orifice openings of dimensions 10.4 m (W) x 14 m (H) with crest level at El. 216 m. Radial gates have been provided at the downstream face of breast wall for controlling the outflow discharge. A ski-jump bucket of 18 m radius and 40^{o} lip angle, with preformed plunge pool, is provided for energy dissipation.

Hydraulic model studies were conducted on 1:60 scale comprehensive model to assess the discharging capacity and hydraulic performance of spillway and energy dissipator. It was observed that the design outflow flood of 5,000 m^3/ s could be passed with all the three gates fully open, but not with one gate inoperative. It was also observed that the water surface profile was not following the breast wall bottom profile resulting in reduced capacity of the orifice to pass the flow. The bottom profile of the breast wall and downstream profile of spillway are being modified to increase the discharging capacity of spillway.

Studies were also conducted for water surface profiles, pressures and performance of energy dissipator. Water surface profiles indicated that the height of the training walls in the sloping portion should be increased to avoid overtopping. The piezometric pressure distribution on the spillway profile was acceptable. As the tail water level is higher than the lip level of the ski-jump bucket, it was necessary to raise the bucket lip by at least 3 m. In order to avoid uncontrolled erosion of river bed and banks, it was recommended to provide a pre-formed plunge pool for dissipation of excess energy of the ski-jump jet. It is also suggested that discharges lower than 1,500 m^3/ s could be passed through central span by providing divide walls downstream of intermediate piers up to the bucket lip. The divide walls would avoid flaring of ski-jump jet towards banks thereby confining the jet in the middle of the river.

Q = 5,000 m^3/ s, FRL El. 245.15 m

Q = 1,250 m3/ s, FRL El. 245.15 m

Flow Conditions Downstream of Spillway

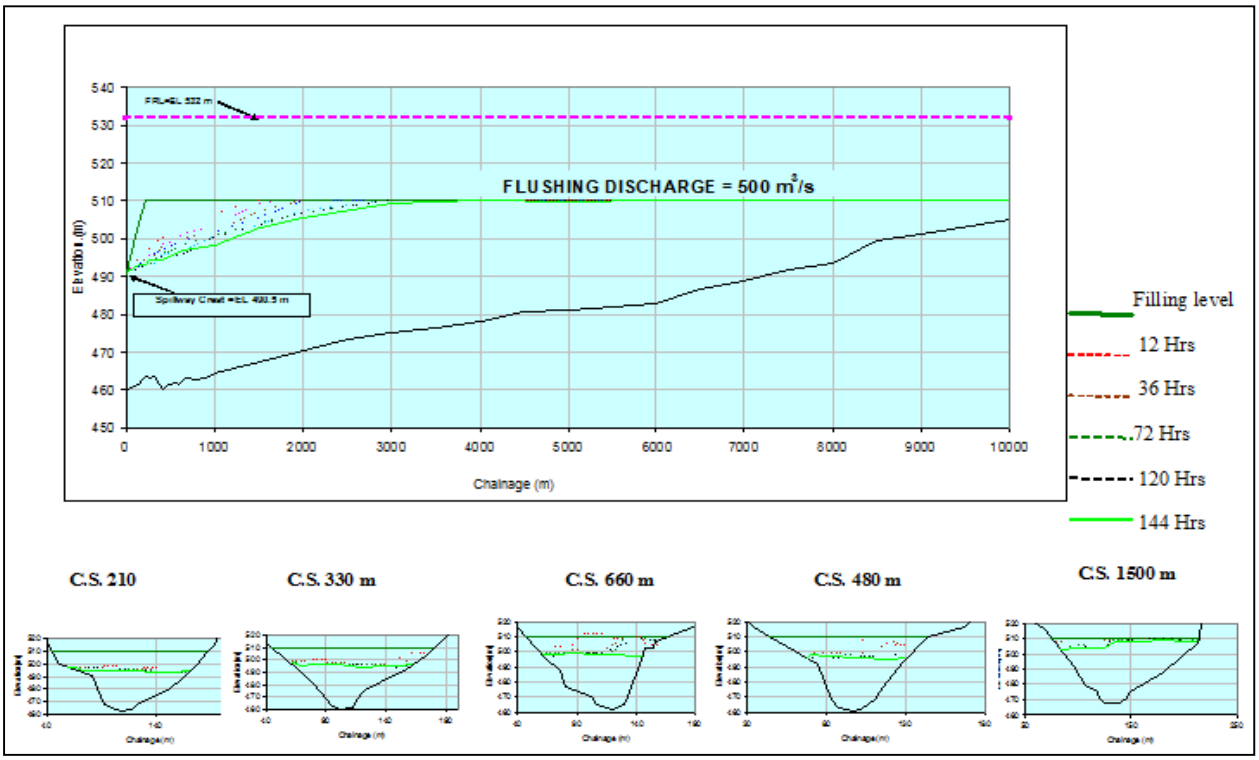
PERFORMANCE OF MODIFIED SPILLWAY AND ENERGY DISSIPATOR FOR KOTLIBHEL HE PROJECT, STAGE II, UTTARAKHAND

Kotlibhel HE Project, Stage II is a run-of-the river scheme on the Ganga River in Devprayag, 30 km downstream of the confluence of the rivers Alakananda and Bhagirathi in Tehri Garhwal District of Uttarakhand. The project envisages construction of an 82 m high and 264.4 m long concrete gravity dam to generate 530 MW of power using a head of 43.67 m. The spillway with crest at EL 422.5 m is 209.7 m long. The original design envisaged an orifice spillway of 9 spans of dimensions 15.3 m (W) x 22.0 m (H) with breast wall and 8 m thick intermediate piers. The spillway is to pass a Probable Maximum Flood (PMF) of 39,750 m^3/ s at FRL EL 458.5 m.. The energy dissipator envisaged was in the form of a ski-jump bucket with a plunge pool downstream. Hydraulic model studies on a 1:90 scale comprehensive model with the original design of the spillway and energy dissipator indicated the discharging capacity of the spillway to be more than adequate, and hence the spillway spans could be reduced to eight. Moreover, the high tail water conditions for the entire range of discharges were affecting the performance of energy dissipator. Provision of hydraulic jump stilling basin was suggested as an alternative to improve the energy dissipation. Studies were conducted to assess the performance of the modified spillway and energy dissipator. It was observed that the PMF could be passed with all the gates fully open and also with one gate inoperative. Mild vortices were observed in the vicinity of breast walls for the end spans and in the wake of the piers. It was observed that the elevations of trunnion and top of training walls were sufficiently high to be affected by the water levels. The piezometric pressure distribution on the spillway profile was acceptable. The front of the hydraulic jump was observed to be upstream of the toe of the spillway on the glacis. It was contained well within the apron of stilling basin. The jump was found to be stable even for 10% retrograded tail water. The performance of stilling basin was satisfactory for both free flow and gated operation of the spillway. It was recommended that a 20 m long solid concrete apron of suitable thickness may be laid on fresh rock downstream of end sill, properly anchored to the rock and keyed at the downstream end to protect against likely scour.

Flow Conditions for Gated Operation of Spillway for Q=9938 m^3/s

PHYSICAL MODEL STUDIES FOR FLUSHING OF THE SEDIMENT FROM RESERVOIR OF KOTLIBHEL HE PROJECT, STAGE I A

Kotlibhel HE Project Stage-I A is proposed on Bhagirathi River in Tehri Garhwal district of Uttarakhand. The project envisages construction of an 82.5 m high and 140 m long concrete gravity dam to create gross storage of 46.17 Mm^3 with net head of 63.33 m for generation of 195 MW (3x 65 MW each) of power. A breast wall spillway with crest at EL 490.5 m would be provided to pass the PMF. CWPRS carried out the studies for flushing of the sediment from reservoir on a 1:100 scale comprehensive model covering a reach of 10 km upstream and 0.5 km downstream of dam axis. Flushing studies were carried with flushing discharges of 500 m^3/s, 800 m^3/s and 1200 m^3/s for different flushing durations after reproduction of the probable siltation profile provided by NHPC with EL 532 m and EL 510 m. These studies indicated that the present layout of the spillway with crest at EL 490.5 m would be efficient to flush out most of the incoming sediment. Sediment load at Kotlibhel-I A was estimated to be 0.695 Mm^3/yr while the quantity of the sediment flushed in 12 hours is 0.690 Mm^3/yr to 1.07 Mm^3/yr for flushing discharges ranging from 500 m^3/s to 1200 m^3/s in case of siltation profile with siltation level up to 510 m. As a result, the reservoir capacity can be restored to a large extent without any difficulty. The prominent flushing discharge would be about 500 m^3/s. Considering incoming annual sediment load of the river, it was recommended that one flushing above a discharge of 500 m^3/s during the rainy season would be sufficient to flush out most of the sediment.



Longitudinal and Cross Sectional Contours After Flushing for Different Durations

COASTAL AND OFFSHORE ENGINEERING
(MATHEMATICAL MODEL AND DESK STUDIES)

DESIGN OF BREAKWATERS FOR PROPOSED DEVELOPMENT OF MEGA CONTAINER TERMINAL AT CHENNAI PORT

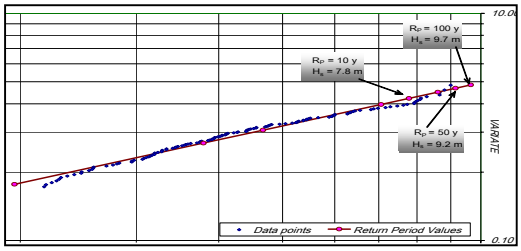
The Chennai Port Trust (CPT) proposes to expand the port facilities by constructing a mega container terminal on the north of the existing outer harbour. The proposed development consists of 1.73 km long northern breakwater, emanating from the eastern breakwater of the fishing harbour and 2.75 km long eastern breakwater, emanating from the existing eastern breakwater.

Studies for storm wave hindcasting and storm surge analysis were carried out to determine the design conditions for the breakwaters. The hindcast storm wave and surge data, obtained by considering the storms which passed by the coast of Chennai between 1951 and 2008 were used for extreme value analysis to determine the wave conditions and storm surge with various return periods. The wave conditions obtained were at a water depth of about 40 m. Wave conditions at the location of breakwaters at Chennai coast (15 m depth) were determined by wave transformation studies.

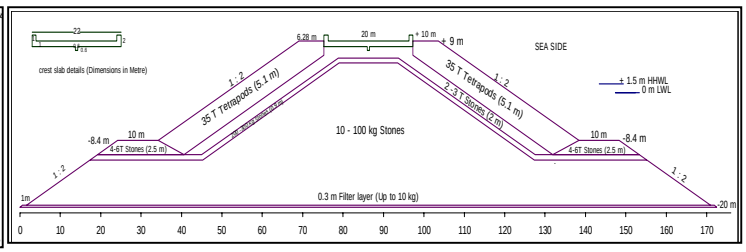
The landward tip of the northern breakwater is at - 3.0 m contour and the roundhead is located at -12 m contour. Accordingly, the trunk sections for different depth and conceptual section for the roundhead at -12.0 m depth were evolved based on empirical methods. The breakwater cross-sections were designed using Tetrapods ranging from 10 t to 25 t in the trunk sections and 30 t in the roundhead. The breakwater was also designed with Accropode II as armour ranging from 3 m^3 to 11 m^3 in the trunk sections and 15 m^3 in the roundhead.

The eastern breakwater is extending from -12.0 m contour and the roundhead lies at -20 m contour. Accordingly, conceptual trunk section for -12.0 m depth to -20.0 m depth and roundhead sections at -20 m depth were evolved. The breakwater was designed using 30 t Tetrapods in trunk sections and 35 t Tetrapods in the roundhead. East breakwater was also designed using 11 m^3 Accropode II in trunk sections and 15 m^3 Accropode II in the roundhead.

Proposed Mega Container Terminal at Chennai Port



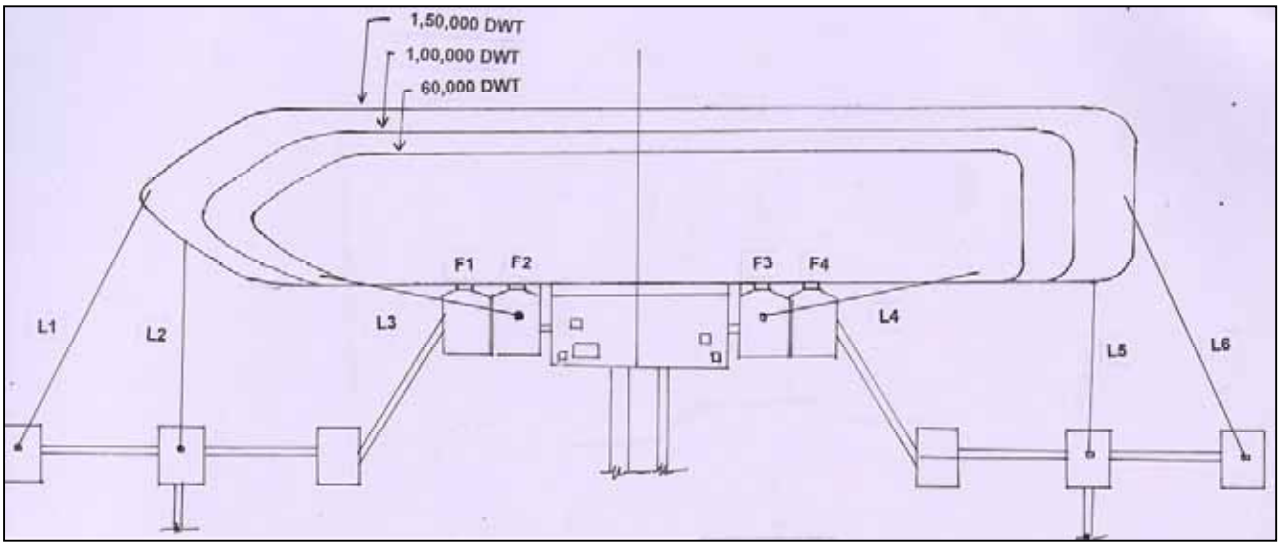
Hindcast Storm Wave Data off Chennai on Weibull Distribution



Tentative Roundhead Section of Extension of Eastern Breakwater at Chennai (-20 m Bed Level)

DESK STUDIES FOR SHIP MOTIONS AND MOORING FORCES AT BERTH FOR NEW MANGALORE PORT, KARNATAKA

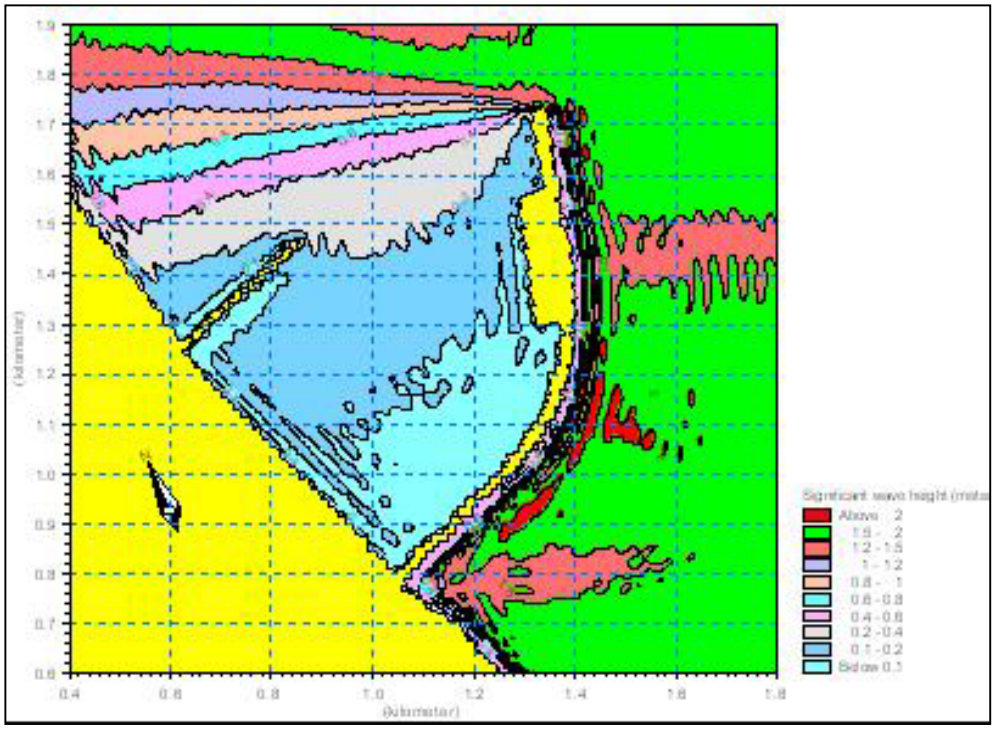
To fulfill the demand of raw material for Mangalore Refineries and Petro Chemicals Ltd. (MRPL), New Mangalore Port (NMPT) has proposed to develop a new oil berth in the southern dock arm named as berth No. 13 to cater to 60000 DWT, 100000 DWT and 1,50,000 DWT oil tankers. Desk studies were carried out to determine the environmental loads due to the action of waves, winds and currents acting on the ship body following the empirical formulations and guidelines stated by Spanish International Standards, PIANC Working Group, etc. The total loads on ship's body were analyzed and resolved along the transverse and longitudinal directions. The berthing energies for the three oil tankers were computed for different approach velocities. Considering all the factors regarding berthing energy, environmental loads, type of berthing structure and its construction, the SUC2000H (RH) fender was found to be suitable to perform. The 80 mm diameter polypropylene rope of 741 KN breaking strength is recommended for ship mooring. No occurrence of fender failure or rope breakage was observed even in extreme environmental conditions considered in the study. It is advised that in extreme conditions the berthing operations or cargo handling operations should be stopped and the tanker should be set free for unberthing operations.



Arrangement of Mooring Lines for the Ships at New Oil Berth, New Mangalore Port

WAVE PROPOGATION STUDIES FOR PROPOSED DEVELOPMENT OF SHIP-BUILDING YARD NEAR CUDDALORE, TAMIL NADU

M/s Goodearth Shipbuilding Private Limited proposes to build a shipbuilding yard near Cuddalore, Tamil Nadu. The harbour layout for Phase-I consists of 1,100 m long south breakwater, 500 m diameter turning circle and a quay along the shore. North side is protected with a 300 m long jetty structure. Area within the harbour is to be dredged to -10 m CD and up to -12 m CD near the berthing jetty. Area between the turning circle and open sea has been kept at -10 m to provide access for approaching vessels. Wave tranquility studies were carried out to optimize the layout of the ship building yard. The studies for inshore wave conditions using OUTRAY model indicated that North-East, East-North-East, East and East-South-East are the predominant wave directions at 12 m depth contour near the region of port development. Mathematical model studies for simulation of wave propagation in the harbour were carried out using MIKE-21 BW model. The studies indicated that wave heights in the harbour were generally within the permissible tranquility limit, except for waves from North-East and East-North-East directions. The wave heights along the quay, turning circle and in the approach channel exceeded the permissible tranquility limit when the 1.5 m high waves were incident from North-East direction. Based on the wave heights at different locations in the harbour, the number of days available for operations was computed. At the quay line, in the turning circle and approach region, wave heights were within permissible limits for about 86 days during North-East monsoon, 113 days during non-monsoon and 116 days during South-West Monsoon, thus totaling 315 days during a year. Studies were also conducted for harbour layout without any breakwater wherein only area of reclamation was reproduced, which was protruding in the sea up to -5 m contour. Studies without any breakwater showed that wave heights are likely to remain within tranquility limits for only about 228 days in a year.



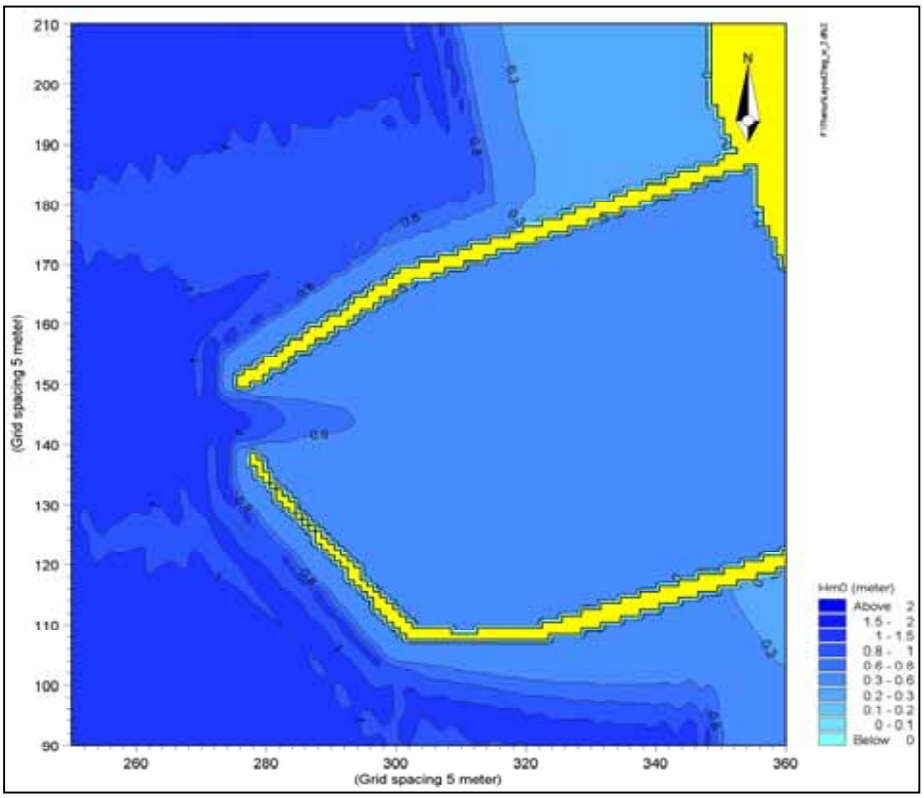
Wave Height Distribution Plot (Hs= 2.0 m ESE Direction)

STUDIES FOR WAVE TRANQUILITY AND SHORELINE CHANGES DUE TO DEVELOPMENT OF FISHERIES HARBOUR AT THANUR

The Harbour Engineering Department (HED), Kerala, has proposed to develop a fisheries harbour at Thanur, on west coast of India at about 25 km south of Beypore, Kerala. In place of the three tentative alternative layouts proposed harbour suggested by HED, a single layout consisting of a shore connected north breakwater of about 1,000 m length, and a shore connected south breakwater of about 950 m length, with an approach channel of width 60 m aligned at 260^0 N considering the predominant wave directions and the direction of littoral drift at the site.

Estimation of littoral drift distribution and shoreline changes due to the proposed development of fisheries harbour were carried out using LITPACK software. This layout was examined for wave tranquility using mathematical model MIKE-21 BW, and was modified to a layout with shore connected north and south breakwaters of lengths about 850 m and 1,050 m respectively.

The studies indicated that for the modified Layout, berths/ jetties on the lee side of south breakwater can be safely operated for about 300 days in a year. The annual net littoral drift was estimated to be of the order of 0.1 M m^3 towards south. Hence, deposition on north side of the north breakwater, and erosion on the south side of the south breakwater would take place at Thanur site. After 10 years, the maximum cross-shore advancements/ recession on north/ south side is predicted in the range of 100 m and its long shore impact would be felt in the range of 2 to 3 km. It was suggested that the coastline in the range of 2 to 3 km on south side, which is prone to recession, may be protected by sea wall/groynes.



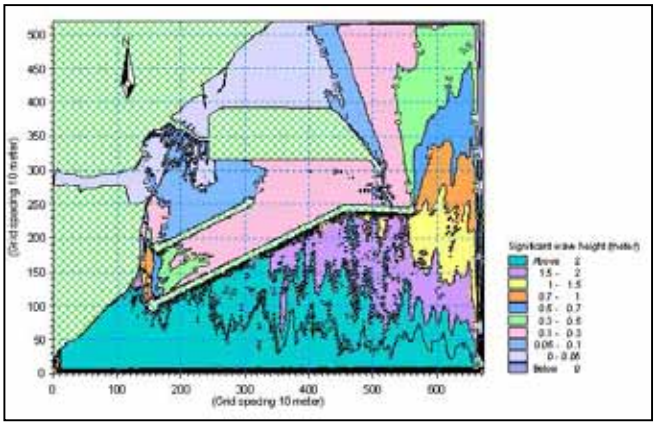
Wave Height Distribution Plot

MATHEMATICAL MODEL STUDIES FOR DEVELOPMENT OF OUTER TO OUTER HARBOUR AT VISAKHAPATNAM

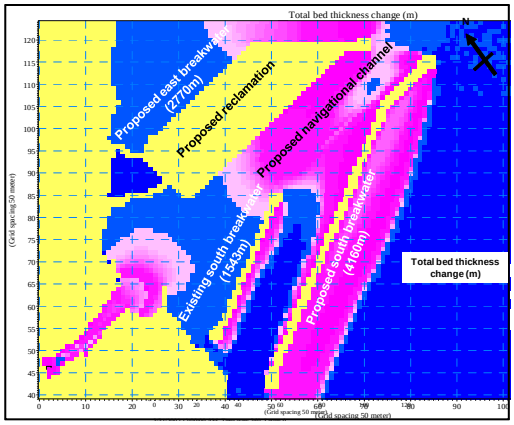
The Visakhapatnam Port Trust proposes to develop an outer to outer harbour to cater to future demands of the port. The proposal is to construct a breakwater of length 4,160 m in the south of the existing southern breakwater and to extend the existing north breakwater by a length of 2,770 m in the east direction. The existing turning circle in the outer harbour, and the proposed turning circle in the outer to outer harbour of diameter 610 m, would be dredged to -21 m. The approach channel and the proposed outer channel of width 400 m would be dredged to -22 m. Mathematical model studies were carried out using hydrodynamic (HD) near-shore spectral wave (NSW) and mud transport (MT) modules of MIKE 21 software for examining wave tranquility and tidal hydrodynamics / siltation aspects of the proposal to suggest suitable / optimized layout for smooth operations at berths throughout the year.

The wave tranquility studies were carried out in two stages. First, the wave parameters of wave height, period and direction were transformed from deep water to 30 m depth using OUTRAY model. Simulation of wave propagation from 30 m depth to the site of development was then carried out using MIKE 21–BW model to obtain wave tranquility at different locations inside the harbour. The studies indicated that with the proposed layout of the Outer to Outer harbour, desired protection at the proposed site is possible throughout the year.

The studies for tidal hydrodynamics indicated that the flow was generally smooth without significant circulation. The magnitude of currents inside the outer harbour was found to be reduced. The magnitude of currents in the outer to outer harbour was of the order of 0.4 m/s while that outside the harbour was of the order of 0.5 m/s. The studies for siltation indicated that the zone of siltation would be mainly between the proposed reclamation and southern breakwater and in the southern adjacent region of the south breakwater. Average deposition in the existing and proposed harbour area was estimated to be 0.21 m/year and 0.28 m/year, respectively. It was further found that the annual maintenance dredging required in the proposed harbour area would be of the order of 1.2 Mm^3.



Wave Height Plot for Proposed Layout of Outer to Outer Harbour



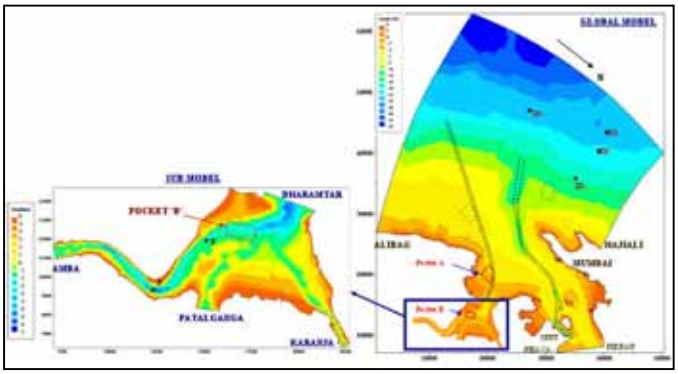
Siltation Pattern Under Proposed Condition during Monsoon Season (At the End of 30 days Simulation)

MATHEMATICAL MODEL STUDIES FOR DEVELOPMENT OF PORT FACILITIES FOR NAVI MUMBAI SEZ

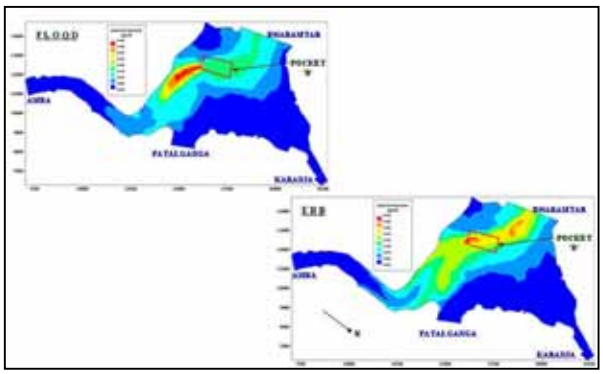
The development of Navi Mumbai Special Economic Zone (NMSEZ) involves deepening of creeks and rivers for facilitating navigation, creation of backup areas, and construction of jetties and a port at Rewas. Out of the estimated 228 Mm^3 of dredging involved, about 126 Mm^3 of sand will be used for onshore reclamation, and the remaining soft clay will have to be disposed off safely in the offshore. Studies were conducted to find the flow pattern in the channel, siltation in the channel and suitable place for the dredged spoil.

Two separate models, one for the offshore area (global model) and the other for creek area (sub model), were used for carrying out these studies using two-dimensional Finite Element Modeling (FEM) software Telemac-2D. The field data required for running and calibration of the models were collected by CWPRS. The studies on flow conditions for global model using software Telemac-2D indicated that after deepening of the channel, the flow gets more aligned along the channel. Sedimentation studies using software Telemac-2D indicate that the total annual silt deposition would be about 8.23 Mm^3 and 9.10 Mm^3 for the channel deepened to -14.5 m and -17.5 m, respectively. The annual maintenance dredging for channel in the Karanja creek was estimated as 0.8 Mm^3 and 1.0 Mm^3 for deepening of -4.5 m and -7.5 m, respectively; while for the Amba River, it was 0.75 Mm^3 and 1.1 Mm^3 for a channel deepening of -4.5 m and -9.0 m, respectively.

The rise in suspended sediment concentration in the vicinity of dredging would be a temporary phenomena and the background concentration would be restored once the dredging is discontinued. Based on the dispersion studies using software Telemac-2D, offshore dumping site DS_4 with geographical coordinates 18° 49' 00"(± 30") N and 72° 37' 30"(± 30") E was recommended for safe disposal of 102 Mm^3 of dredged spoil. The sedimentation model studies indicated a maximum deposition of 0.36 m/annum at the dumping location DS_4 spreading over an area of about 80 km^2.



Domain of Considered Global and Sub Models



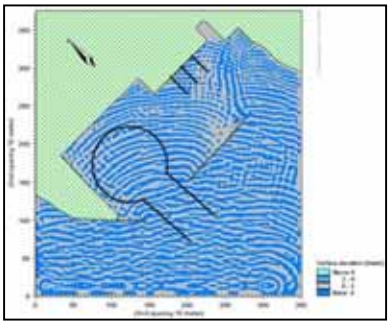
Dispersion of Dredged Material due to Sand Mining

HYDRAULIC MODEL STUDIES FOR DEVELOPMENT OF HARBOUR AT SUTRAPADA, GUJARAT

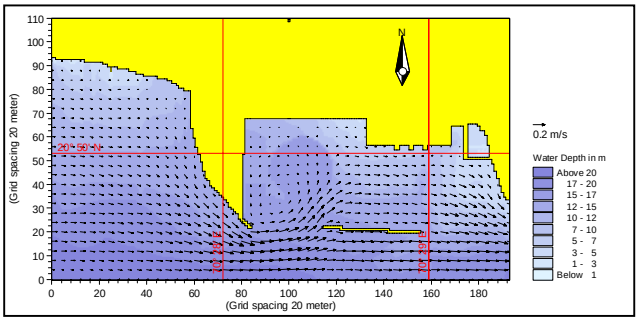
M/s Gujarat Maritime Board (GMB) has proposed to develop harbour facilities at Sutrapada on Sourashtra Coast between Veraval and Muldwaraka. Wave tranquility, tidal hydrodynamics and sedimentation studies were carried out for the development of fisheries harbour as well as commercial harbour at Sutrapada. The layout proposed by GMB consists of two breakwaters, viz. a western breakwater (1,386 m long) and southern breakwater (660 m long).

Wave tranquility studies were carried out to optimize the harbour layout using OUTRAY and MIKE-21 BW models. The studies indicated that extension of western breakwater by 200 m and extension of south breakwater by 140 m, as well as re-orientation of the south breakwater would be essential to obtain the desired tranquility in the harbour area. Tidal hydrodynamics and sedimentation studies were carried out using mathematical models MIKE21-HD and MIKE 21-MT, respectively. These studies indicated that the currents in the offshore region are of the order of 0.2 m/s. The optimized layout of the breakwater changes the flow pattern and some circulations are observed in the harbour area. However these circulations are weak. The siltation in the harbour would be of the order of 0.3 Mm^3 per year, which is required to be dredged to maintain the desired depths.

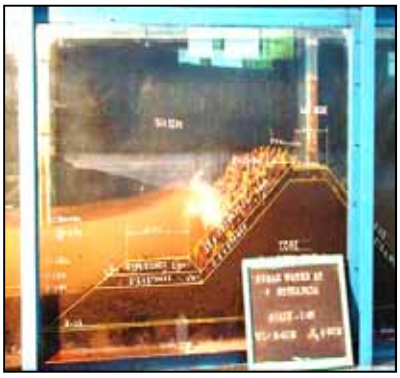
Desk and wave flume studies were also carried out to design the breakwater cross-sections and the roundheads. Initially, a conceptual design of breakwater cross-sections at various depths of water was evolved using tetrapods in the armour layer and provision of a long toe-berm. These cross-sections as well as the roundheads were confirmed and optimized through wave flume studies on a 1:45 scale geometrically similar model. The trunk section at –14 m depth contour consisted of 15 t tetrapods on 1:2 slope in the armour layer, whereas, the roundheads consisted of 25 t tetrapods on 1:2 slope in the armour layer. A 15 m wide toe-berm was provided for trunk and roundheads to dissipate the wave energy.



Wave Propagation Optimized Layout of the Port



Flow Pattern During Peak Flood

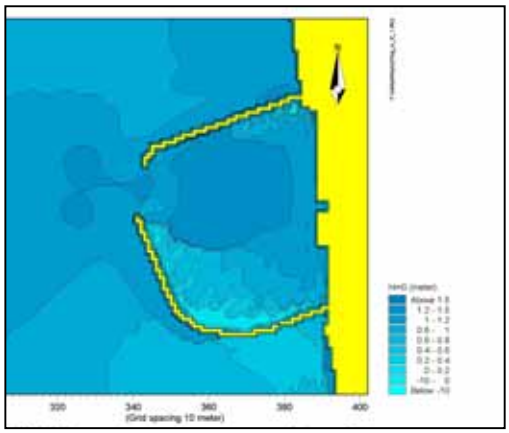


Flume Studies for Action of Random Waves (H_S = 6.8 m) at HWL

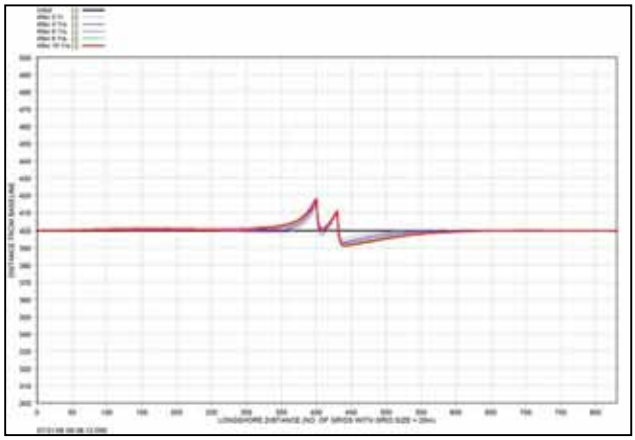
STUDIES FOR WAVE TRANQUILITY AND SHORELINE CHANGES DUE TO DEVELOPMENT OF FISHERIES HARBOUR AT VELLAYIL, KERALA

The Harbour Engineering Department (HED), Kerala, proposes to develop a fisheries harbour at Vellayil near Calicut, Kerela. The tentative layout of the harbour suggested by HED was modified considering the predominant wave directions and direction of littoral drift. The modified layout of the harbour basin consists of a shore-connected north breakwater of about 650 m length, and a shore-connected south breakwater of about 495 m length with an approach channel of width 60 m aligned at 247^0 N. This layout of the proposed harbour was examined for wave tranquility by the mathematical model MIKE21-BW, and further modifications were suggested to achieve the desired wave tranquility. An alternative layout, with shore connected north and south breakwaters of lengths about 530 m and 750 m respectively with an approach channel of width 60 m aligned at 250^0 N was finally examined for wave tranquility, and this layout was found to be more suitable.

Model studies indicated that the finalized Layout with berths/ jetties in the lee side of north and south breakwaters could be safely operated for about 280 days in a year. Mathematical model studies for estimation of littoral drift distribution and shoreline changes due to the proposed development of fisheries harbour were also carried out using LITPACK software. The annual net littoral drift was estimated to be of the order of 0.04 M m^3, with its direction most likely towards north. Hence, deposition on south side of the south breakwater and erosion on the north side of the north breakwater would take place at Vellayil site. After 10 years, the maximum cross-shore advancements on south side and recession on north side is predicted to be in the range of 10 m to 20 m and its long shore impact would be felt in the range of 1 km to 1.5 km. The coastline in the range of 1 km to 1.5 km on north side which is prone to recession is required to be protected by coastal protection works such as sea wall / groins as per standard guidelines.



Wave Distribution for Incident Wave Height of 1.0 m from Westerly Direction



Shoreline Changes After 2, 4, 6,8,10 Years due to Development of Fisheries Harbour

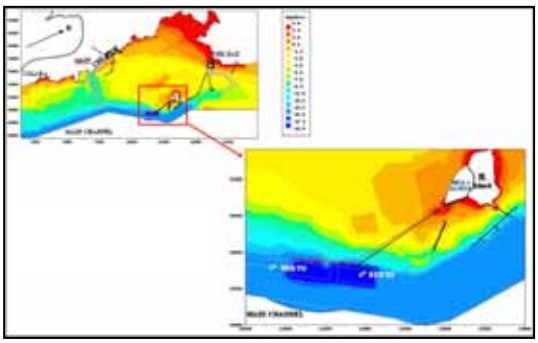
MATHEMATICAL MODEL STUDIES FOR THE PROPOSED FIFTH OIL BERTH AT JAWAHAR DWEEP

There are four berths J1 to J4 at Jawahar Dweep Island in Mumbai harbor for handling oil tankers. The Vth berth is proposed along the main navigational channel in line with IVth oil berth. The berth is proposed to be connected to Jawahar Dweep through approach trestle on piles. The 450 m wide main navigational channel in front of the proposed berth, presently being maintained at -11.0 m CD, is proposed to be deepened to -14.5 m below CD. It is also contemplated to reclaim about 24 ha at southwest of Jawahar Dweep for augmenting storage capacities. Studies were conducted for tranquility flow conditions, siltation and identification of dumping ground.

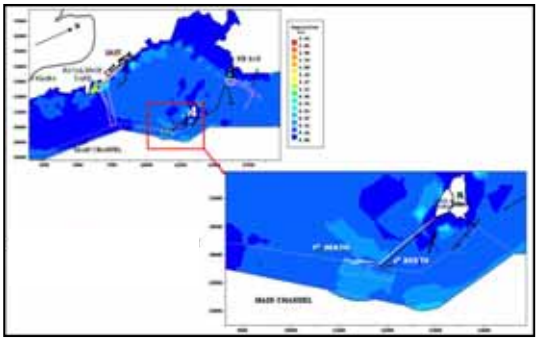
The measured wave and wind data in Mumbai harbour was used for wave transformation studies using MIKE-21 FM software. The wave transformation studies for predominant wave directions of West-South-West, West and West-North-West having 3 m, 4 m and 3 m wave heights (H_s) respectively with period of 10 s showed negligible variation in wave height at outer wave rider buoy location (18^0 52' 14" N, 72^0 49' 50" E). The wave model was calibrated using wind as calibration parameter. The calibrated wave model was used for the transformation of predominant wave directions. The appropriate wind-wave growth along with wave condition was simulated to assess the wave conditions at Vth oil berth. The studies indicated that at the Vth oil berth near Jawahar Dweep, oil tankers can operate for about 330 days in a year, which is found suitable from tranquility consideration as per the downtime proposed by MbP.

One global and two sub-models were developed using Finite Element Modelling (FEM) software Telemac-2D to understand various global and local phenomena. The models were initially calibrated for flow conditions using the field data collected while the calibration for silt model was carried out with the help of dredging data obtained from the project authorities. The mathematical model studies indicated that the proposed Vth oil berth location is suitable and since the berth and its approach are proposed to be on piles, it would not affect the flow pattern at the berth. It is observed that the proposed reclamation on the southwest of the Jawahar Dweep has negligible effect on the prevailing flow regime of the region.

Sedimentation studies using MIKE 21 MT indicated that an additional siltation of 22,252 m^3 per year would be deposited in the areas of dredging. Based on the model studies, the offshore dumping ground DS3 was recommended for dumping of additional 3 Mm^3 of dredged material resulting from the proposed Vth oil berth. The maximum rate of dumping at this site should be restricted to 100,000 m^3 per day. The studies indicated that the dumped materials would not reach the channel or shore, and most of the materials are likely to be carried by tidal currents and there is no likelihood of any shore line changes. Further the bottom deposition at dumping site also would also not exceed 30 cm.



Bathymetry for the Model Domain

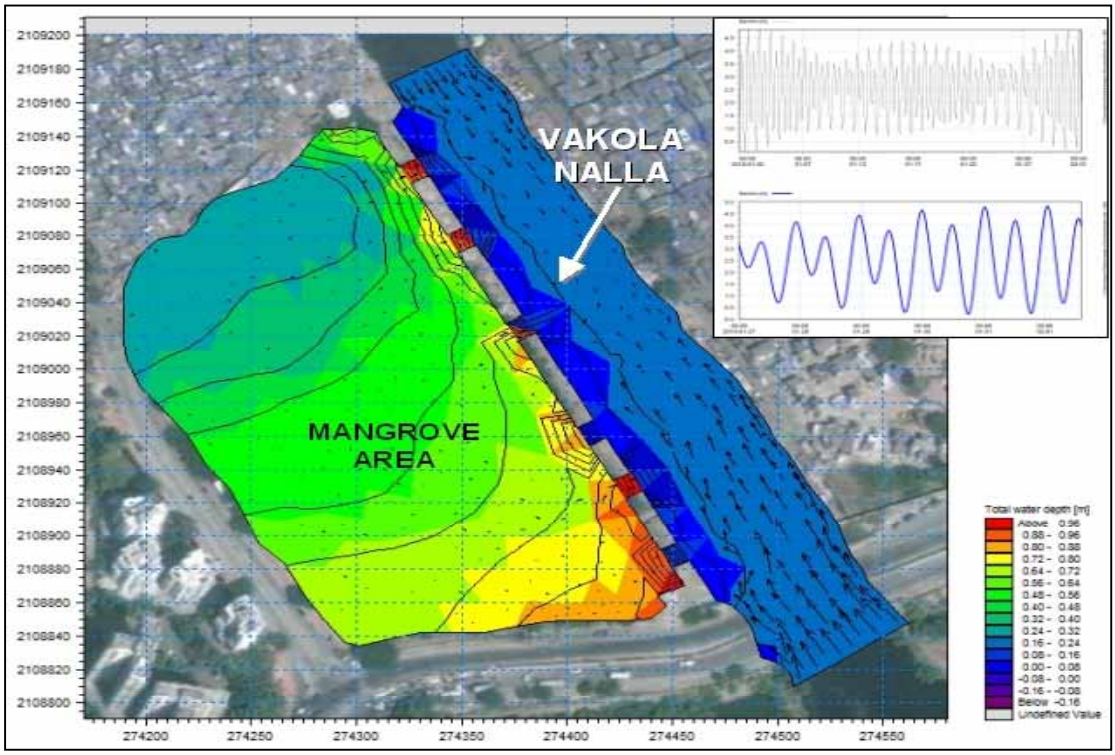


Annual Silt Deposition Pattern

MATHEMATICAL MODEL STUDIES FOR TIDAL EXCHANGE IN THE MANGROVE AREA ADJACENT TO VAKOLA NALLA, MUMBAI

The Mumbai Metropolitan Region Development Authority (MMRDA) has constructed an RCC retaining wall along the right bank of Vakola Nalla, Mumbai under Mithi River Channelization programme for mitigation of floods. A Mangrove patch admeasuring 180 m X 300 m exists on the right bank, at the junction of Vakola Nalla and Mithi River, and the said RCC Retaining wall separates the mangroves from the nalla. In order to facilitate the necessary tidal exchange for the mangroves MMRDA provided seven numbers of 900 mm diameter RCC Hume pipes across the retaining wall. Studies were also carried out using two-dimensional mathematical model MIKE 21 HD to verify the adequacy of these pipes in providing the required tidal exchange.

The mangrove area under consideration is part of the Mahim Creek where the tide propagates through the Mahim Bay from the Arabian Sea. The tides in this region are of mixed nature exhibiting diurnal inequality and the tidal range varies from 1.0 m to 4.5 m. The lowest low water is 0.42 m and the highest high water is 4.81 m. The tidal exchange was simulated in the model for the extreme tidal variations and it was found that the seven numbers of 900 mm RCC Hume pipes are able to provide adequate tidal exchange and also ensure tidal asymmetry and minimum water retention at low tide. It was, however, recommended to check illegal dumping of debris and reclamations to ensure free flow of tidal water and prevent choking of the pipelines.

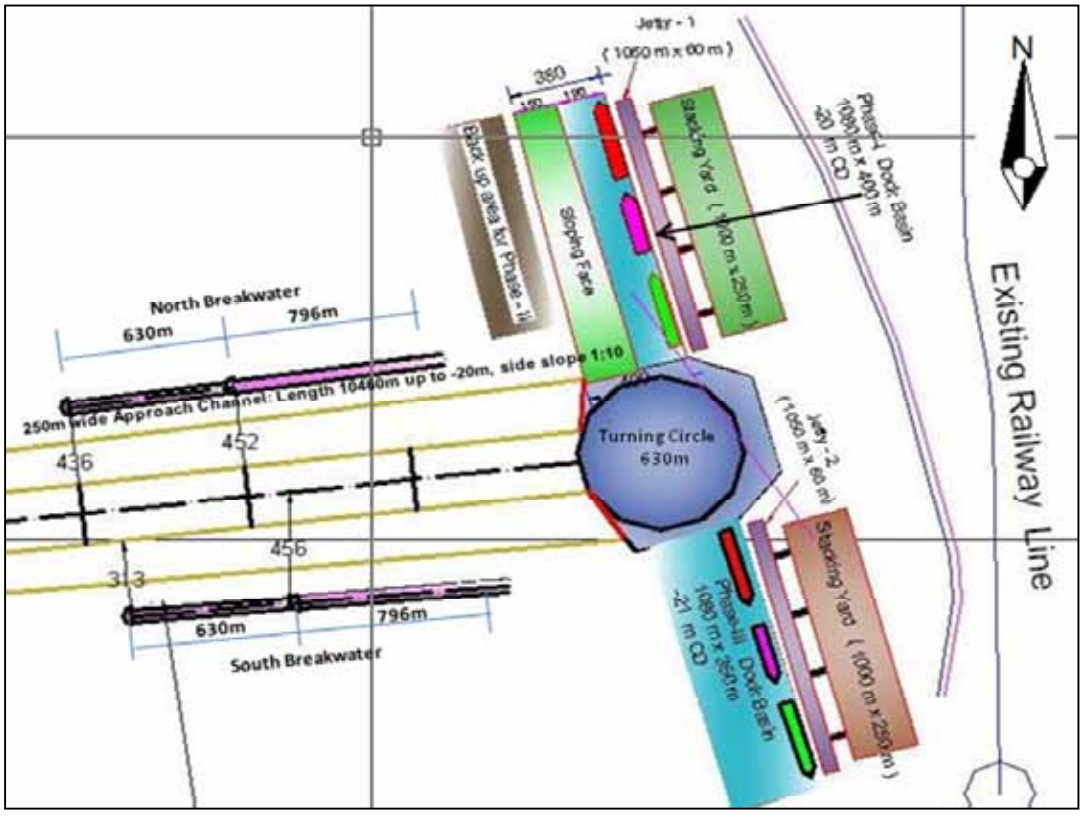


Total Water Depth in Mangrove Area at Low Water (Tidal Exchange Condition)

WAVE TRANQUILITY STUDIES FOR DEVELOPMENT OF ALL-WEATHER PORT AT HALDIPUR, KARNATAKA

M/s Mineral Enterprises Limited (MEL) proposes to develop deep water all weather port at Haldipur in Karnataka on the west coast of India. In this regard, wave tranquility studies were carried out to suggest a suitable layout of breakwaters. Ship observed offshore wave data reported by IMD were utilized for computation of wave transformation from deep waters to the near shore of Haldipur using OUTRAY model. The predominant wave directions of wave approach in 20 m depth obtained from the results were from WNW, West, WSW and SW directions with percentage occurrence of 14%, 33%, 13% and 10%, respectively. Wave tranquility inside the harbour was studied for these wave directions using MIKE 21-BW model for layout proposed by WAPCOS comprising of north and south breakwaters of 1426 m length each.

The studies indicated that wave heights in the harbor and turning circle are well within the permissible limit for the entire year. Further, model studies carried out for optimization of breakwater length, with north and south breakwaters of 800 m length each, indicated that the wave heights in the harbor and turning circle will be within the permissible limit throughout the year. Based on the results of the studies and the seabed properties at the site, the layout of the breakwater would be decided by the project authorities.

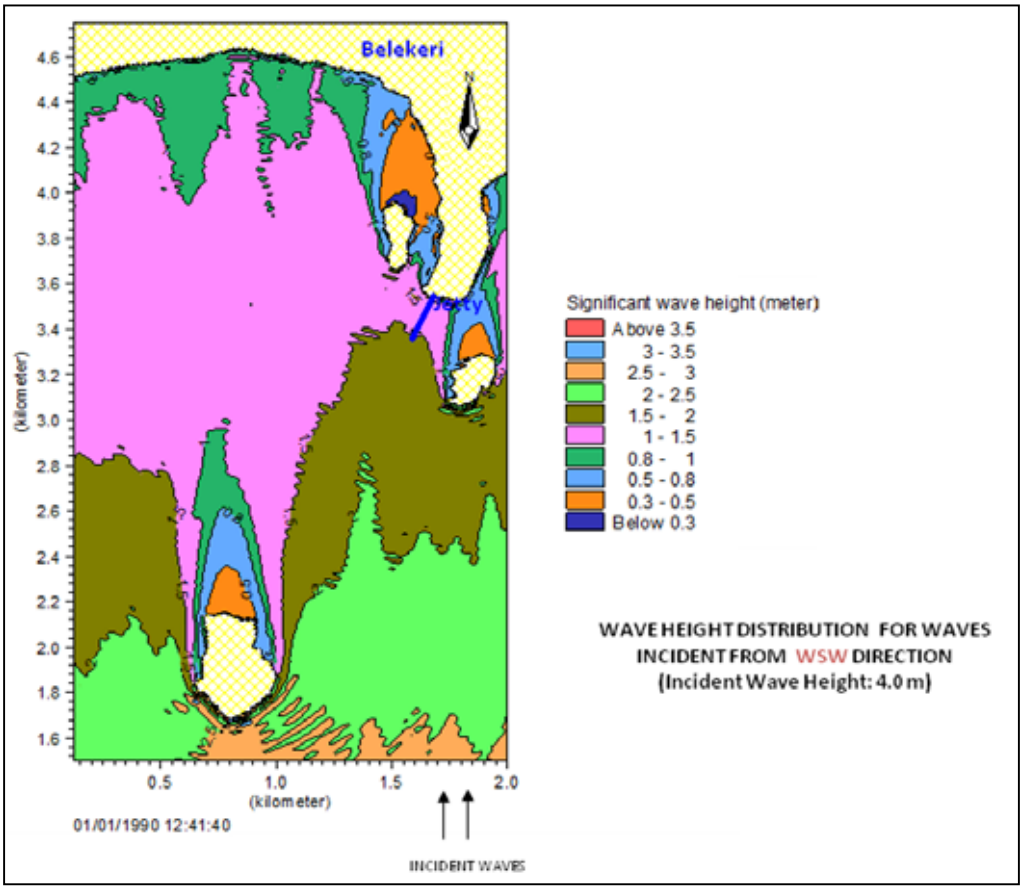


Proposed Harbour Layout

WAVE TRANQUILITY STUDIES FOR DEVELOPMENT OF BELEKERI PORT, KARNATAKA

Ports and Inland Water Transport (Port & IWT) Department, Karnataka proposes to develop a commercial Harbour at Belekeri, near Karwar. Presently, three barge loading points are in operation during fair weather without any protective breakwater. Jetty has been used for barges of 1000t–2000t capacity, requiring a draft of about 3 m. Wave tranquility studies were carried out to assess the wave climate under the existing conditions without any breakwater.

Ship observed wave data reported by the India Meteorological Department were utilized for determining the near shore wave conditions at Belekeri Port. The predominant wave directions of wave approach in 7 m depth were from West, WSW and SW directions with percentage occurrence of 14%, 41% and 21%, respectively. Wave tranquility near the jetty was examined for these wave conditions using MIKE-21 BW model. The model studies indicated that the wave heights near the existing jetty are within the permissible limit of 0.5 m for about 170 days in a year.



Wave Height Distribution for Incident Wave Height 4.0 m from WSW Direction

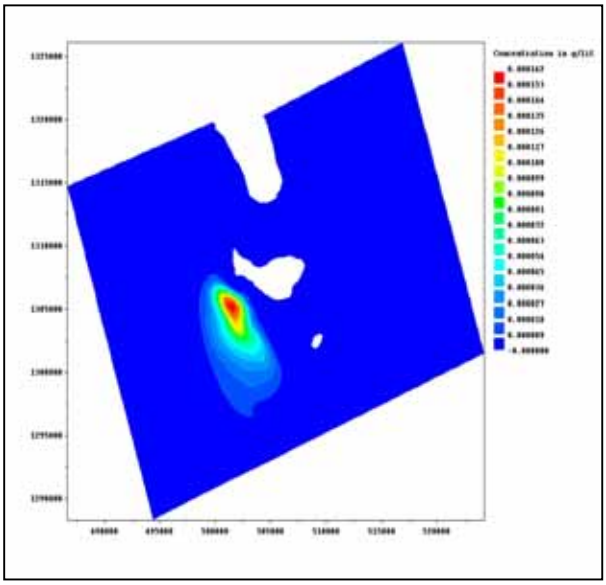
STUDIES FOR IDENTIFICATION OF SUITABLE DUMPING GROUND FOR DISPOSAL OF DREDGED MATERIAL AT NEIL ISLAND, ANDAMAN

Neil Island at Andaman is situated at about 20 Nautical miles west of Port Blair. The Andaman Lakshadweep Harbour Works (ALHW) are facing problem of berthing passenger ships at the existing jetty at Neil Island due to inadequate depth. The ALHW have a proposal for carrying out dredging at jetty berth. The quantity of material to be dredged is of the order of 32,000 m^3. The material needs to be dumped at suitable location so that it does not reach the dredged area, as well as shoreline of Neil and the nearby Havelock Island. Mathematical model studies were carried out to identify suitable location of dumping ground using Telemac-2D software.

The hydrodynamic simulation was first carried out for conditions prevailing at Neil Island, and it was then coupled with sediment model for dispersion studies to identify suitable location of dumping ground. The model was run for entire tidal cycle to estimate likely dispersion of dumped material. The disposal of dumped material was simulated in model as per schedule proposed by ALHW.

The studies for dumping at location (Latitude $11^0$49'59"N; Longitude 93^0 0' 11" E (+/- 3") revealed that the dumped material moves to and fro along with the flood and ebb currents in the form of cloud of varying concentration towards north and south, respectively. The studies also revealed that the dispersion cloud does not reach the dredged area as also shoreline of Neil/Havelock Island. The location being in deeper depths of the order of 40 m is found suitable to dump 32,000 m^3 of dredged material from jetty area at Neil Island. Further, this location does not come in main navigation channel. Hence, the proposed dumping location is suitable for dumping of dredged material from jetty area of Neil Island.

Location Map of Neil Island



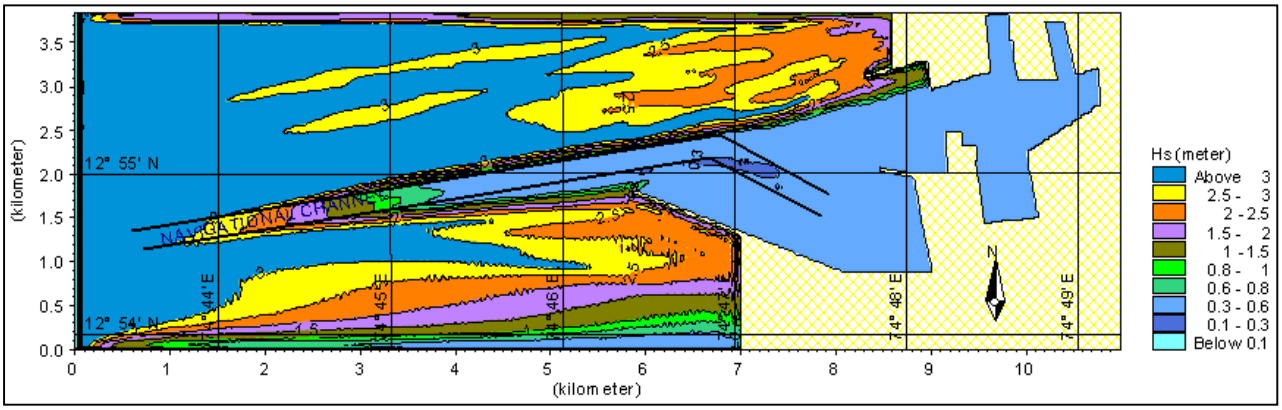
Dispersion of Dumped Material at Neil Island

WAVE PROPAGATION STUDIES FOR PROPOSED DEEPENING OF EXISTING CHANNEL AND DEVELOPMENT OF OUTER HARBOR FOR LNG TERMINAL AT NEW MANGALORE PORT

New Mangalore Port (NMPT) authorities propose to develop an LNG terminal in the Outer Harbour to cater to the requirements of LNG for power projects coming up in the vicinity. Mathematical model studies for wave propagation were carried out to check the adequacy of the harbour layout to achieve desired wave tranquility in the Outer Harbour.

The Port Authorities proposed two alternatives for outer harbour layout which are mirror images of each other. Alternative-I consists of development of outer harbour in the southern side of the existing port, whereas Alternative-II is for development of outer harbour in the northern side. Outer harbour proposal has a 3300 m long breakwater, 600 m diameter turning circle and the existing approach channel deepened to -18.5 m depth. Considerable area between the existing and proposed breakwaters is proposed to be reclaimed.

Wave transformation studies from deep water to shallow coastal area using software OUTRAY revealed that waves are incident from SW, WSW, W and WNW directions in the near shore region. Alternative layout II is directly exposed to waves incident from SW, WSW and West directions. Therefore, wave tranquility studies were carried out with Alternative-I using software MIKE 21 BW, which gives adequate protection to the proposed berthing area from waves incident from SW direction. Mathematical model studies for wave tranquility revealed that the proposed port layout with Alternative-I consisting of 3300 m long southern breakwater is adequate to achieve the desired wave tranquility of 1.0 m in the outer harbour area. As such, Alternative-I has been recommended for the proposed development of outer harbour at New Mangalore Port.

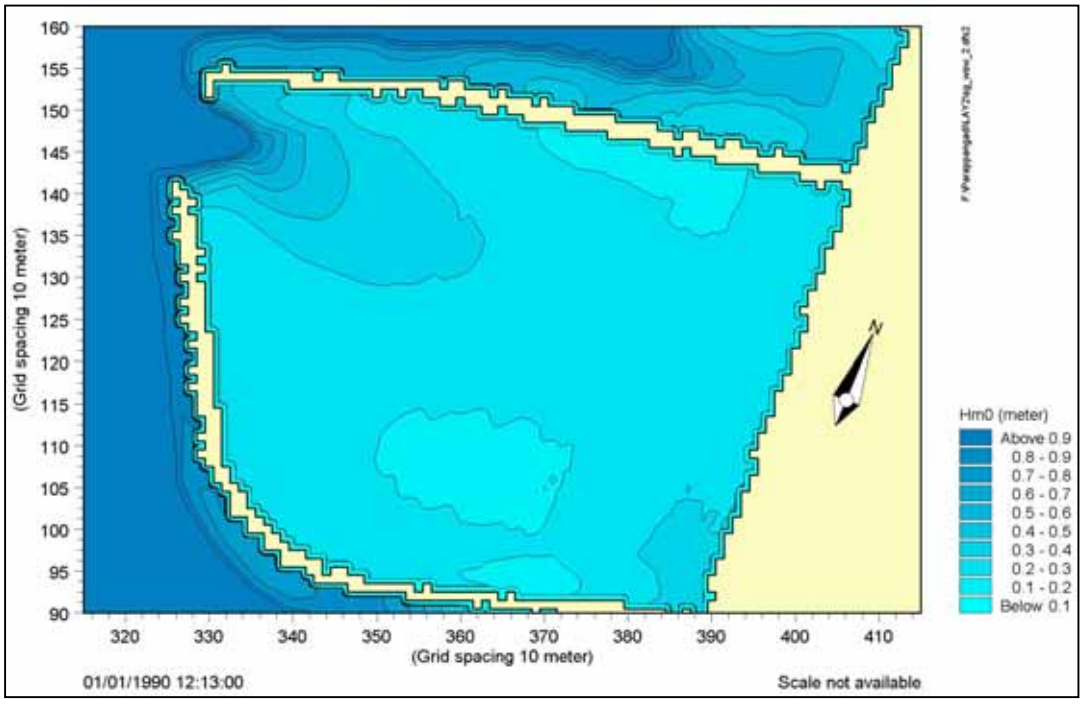


Wave Height Distribution Plot Hs =3.5 m, Period = 10 sec, and Direction = 259^0 N

STUDIES FOR WAVE TRANQUILITY AND SHORELINE CHANGES DUE TO DEVELOPMENT OF FISHERIES HARBOUR AT PARAPPANAGADI, KERALA

The Harbour Engineering Department (HED), Kerala, has a proposal to develop fisheries harbour at Parappanangadi at about 15 km south of Beypore on the west coast Kerala. Two tentative layouts of the harbour proposed by HED were analyzed for wave tranquility and littoral drift using mathematical models MIKE 21 and LITPACK, respectively. Layout-I with a shore connected north breakwater of about 780 m length and a shore connected south breakwater of about 635 m length with an approach channel of width 60 m aligned at 270^0 N was not found suitable as the waves in the harbor were higher than the wave tranquility requirement of 0.3 m. Considering various alternatives for relocation of the harbour for avoiding the possible choking of the Murithodu (storm drain) in the vicinity, Layout-II of the harbour with shore connected north and south breakwaters of lengths about 710 m and 900 m with an approach channel of width 60 m aligned at 250^0 N was found suitable.

The studies indicated that the proposed Layout II, with berths/ jetties in the lee side of both the breakwaters, can be safely operated for about 300 days in a year. The annual net littoral drift was estimated to be of the order of 0.1 M m^3 with its direction towards south. As such, deposition on north side of the north breakwater, and erosion on the south side of the south breakwater would take place at Parappanangadi site. After 10 years, the maximum cross-shore advancements/ recession on north/ south side was predicted in the range of 100 m, and its long shore impact would be felt in the range of 2 to 3 km. The coastline in the range of 2 to 3 km on south side, which is prone to recession, is required to be protected by coastal protection works such as sea wall / groins. Also, periodical maintenance of the Murithodu storm drain mouth in the vicinity of the south breakwater may be required for keeping the mouth open.

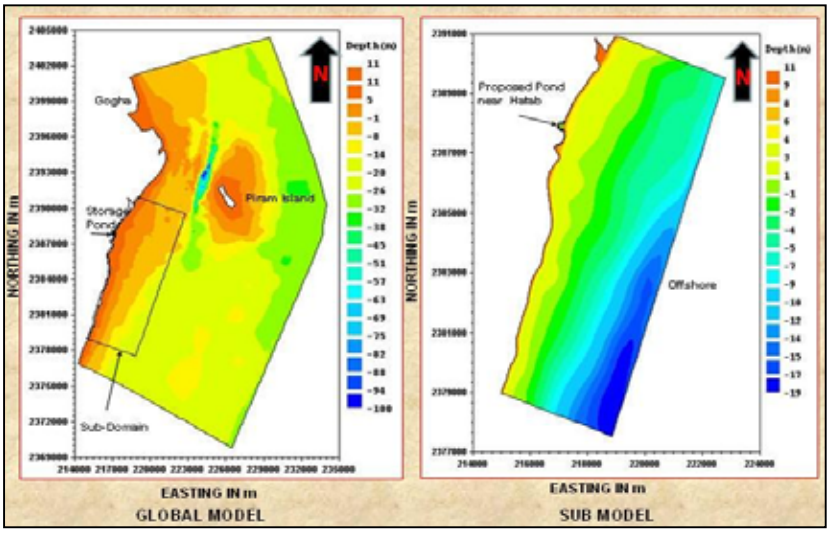


Wave Distribution Plot for Layout 1 for Incident Wave Height 3.0 m from Westerly Direction

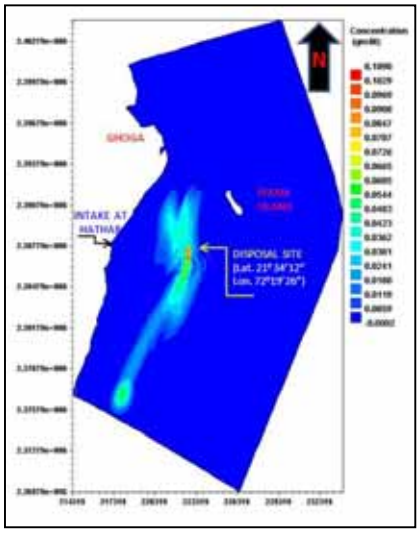
MATHEMATICAL MODEL STUDIES FOR HYDRODYNAMICS, SILTATION AND IDENTIFICATION OF DUMPING GROUND FOR LIGNITE BASED TPP AT PADVA, GUJARAT

M/s Bhavnagar Energy Company Limited (BECL) has proposed to set up a 500 MW (2x250 MW) lignite based thermal power plant near village Padva in Bhavnagar District of Gujarat. It was proposed to make use of sea water for cooling of condensers and auxiliaries. Mathematical model studies were carried out using Telemac 2D software to check the adequacy of storage pond and intake channel for continuous supply of seawater to condenser cooling and also for estimation of siltation in the cooling pond and identification of suitable dumping ground. The oceanographic data was supplied by M/s BECL and M/s Tata Consulting Engineers (TCE) provided the tentative layout plan of storage pond, intake channel and onshore pump house as an intake system.

A Global model covering 418 km^2 and sub model covering 55 km^2 were used for the present study, which were calibrated for the prevailing hydrodynamic conditions. The studies revealed that the storage pond of size 120 m x 130 m with bed level at 0.6 m below Chart Datum, as suggested by M/s TCE, was adequate even for the lowest high water level of 6.0 m with the pumping proposed at the rate of 6,200 m^3/ hr. The simulated model was coupled with sediment model to estimate likely siltation in storage pond as well as intake channel. The estimated likely siltation in storage pond was about 0.1 Mm^3 / year with no significant siltation in the intake channel. The global model, coupled with dispersion model, indicated that the dumping ground at Latitude 21^0 34' 12" and Longitude 72^0 19' 26" is suitable to dump desilted deposited material at the rate of about 400 m^3/hr once before monsoon and non-monsoon in a year.



Bathymetry of Global and Sub-Model Domains

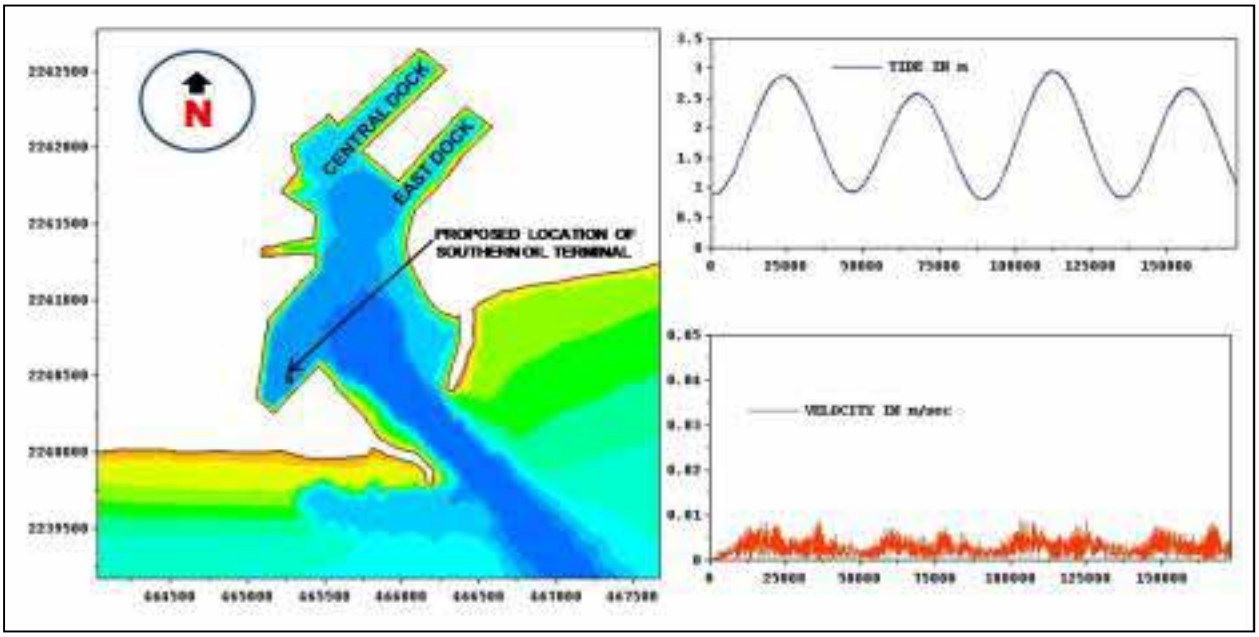


Dispersion of Dumped Material

STUDIES FOR FINALISING ALIGNMENT OF OIL JETTY IN NEW SOUTHERN DOCK AREA AT PARADIP PORT

Paradip Port is one of the major ports of India on the East coast in Orissa. The port is having berthing facilities to cater to bulk cargo such as coal, iron ore, limestone, fertilizers, etc. and a jetty for oil tankers. Under its development plan, Paradip Port Trust proposes to develop a new dock on south side of the existing entrance channel at the root of south breakwater. The proposed dock is planned to provide multipurpose berths as well as oil jetty for oil tankers of capacity 125,000 DWT.

Mathematical model studies were carried out using Telemac-2D software to finalize the alignment of oil jetty at the proposed new southern dock. The oceanographic data available at CWPRS in the vicinity of port area was used for simulating the prevailing hydrodynamic conditions. The mathematical model covered entire Paradip port area and deeper part of sea and was able to simulate very accurately the prevailing flow field, both in terms of maximum current, water level, and the directions of flow during flood as well as ebb. The flow simulation studies indicated that the maximum strength of current at the location of the proposed oil jetty is negligible (1 cm/s) and small circulation / eddies was noticed. The studies also indicated that the proposed development would not have any adverse impact on the flow field at the existing docks / turning circle. As such, the alignment of oil jetty (28^0 N) and layout of new southern dock, proposed by Paradip Port, was found suitable and safe for berthing of 125,000 DWT oil tankers from tidal hydrodynamic considerations.



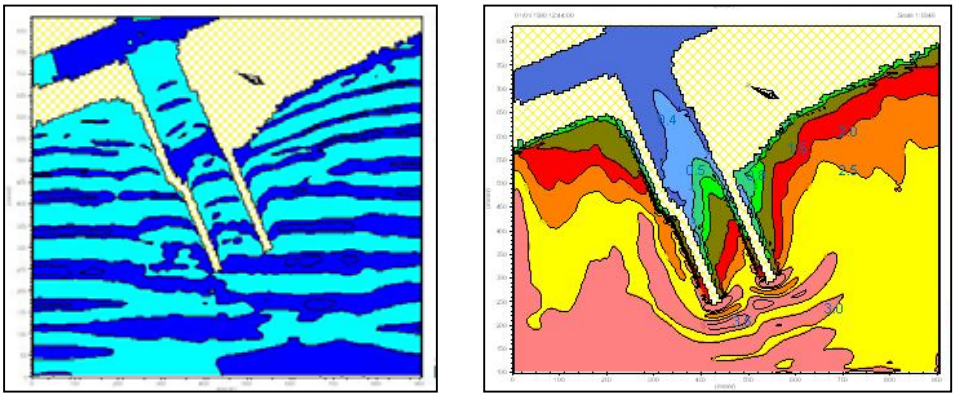
Tide and Velocity Plot at Proposed Oil Jetty Location

STUDIES FOR SHORELINE CHANGES DUE TO DEVELOPMENT OF MUTHALAPOZHY FISHERIES HARBOUR, KERALA

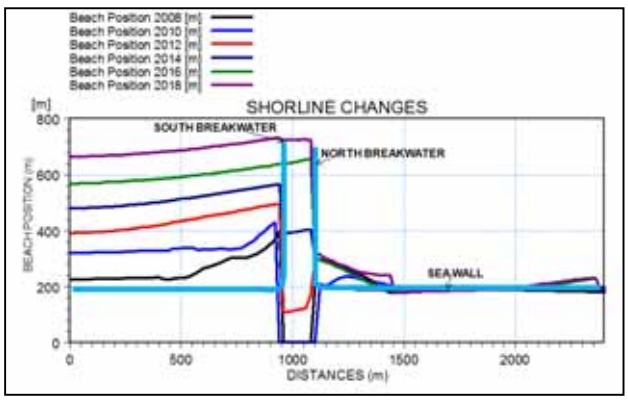
Muthalapozhy fisheries harbour is located at the mouth of Vamanapuram River, which is a coastal inlet on the West Coast of India in Kerala. The inlet gets gradually silted up during early summer and finally closes during the month of February or March. Two breakwaters viz. northern and southern breakwaters of length 410 m and 330 m respectively were proposed by IIT Chennai to protect this inlet. However, these were not able to solve the problem. Mathematical model studies were therefore carried out for evolution of the shoreline changes adjacent to the breakwaters and to assess the tranquility conditions at the entrance and the harbour area. Mathematical models OUTRAY, LITPACK and MIKE 21 BW were used for simulation of near shore wave field, littoral drift/shoreline changes at the site, and wave disturbance in the harbour area, respectively.

The studies indicated that the extension of the south and north breakwaters by 200 m will help in trapping the sediments on southern side of the south breakwater and prevent bypass and subsequent filling of the channel. However, it is predicted that after about 6 years the cross-shore accretion on the south side would be about 220 m, and siltation into the channel will start. Therefore, regular sand bypassing from south to north is essential to prevent erosion of the northern coastline and accretion on the south. The coastline on north side which is prone to recession is required to be protected by appropriate coastal protection works.

Wave tranquility studies with extension of breakwater indicated that wave heights near the entrance of the channel will be about 2-3 m in severe monsoon condition. However, the wave heights in the inner portion of Fisheries Harbour will always be within the permissible limit of 0.3 m.



Wave Propagation and Wave Height Distribution for Incident Wave Height of 3.5 m from WSW Direction



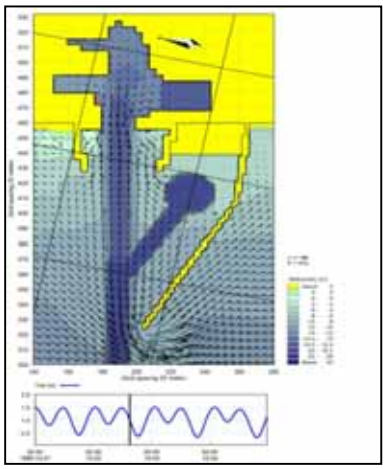
Advancement of Coastline After Proposed Extension of Breakwater by 200 m

MATHEMATICAL MODEL STUDIES FOR PROPOSED DEEPENING OF EXISTING CHANNEL AND DEVELOPMENT OF OUTER HARBOUR FOR LNG TERMINAL AT NEW MANGALORE PORT

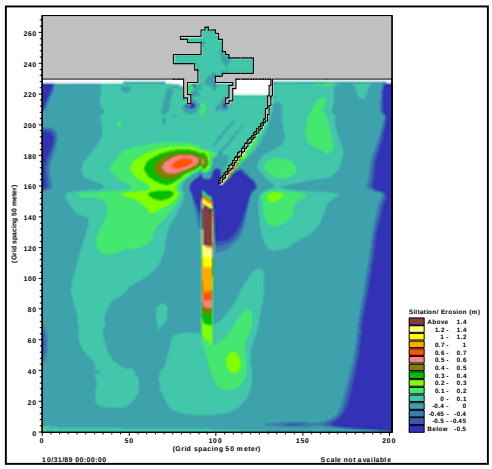
The New Mangalore Port is one of the major ports on the west coast at Panambur 10 km north of Mangalore. It is an all weather port of artificial lagoon type, located between the shoreline and Gurupur River. Two rubble-mound breakwaters of length 770m each on the north and south side are flanking the port entrance at the shore. They are 1362m apart at the shore and converge at the seaward ends to 975 m distance, where bed levels are 7.5 m below the local chart datum. The New Mangalore Port has been developed over last four decades in a stage wise manner resulting in a layout with two dock arms connected to the main port basin.

New Mangalore Port Trust authorities proposed deepening of existing channel and development of outer harbor for a Liquefied Natural Gas (LNG) terminal. The proposal includes two alternatives. Alternative-I with an outer breakwater on the southern side with a total length of 3,300 m (1,300 m + 2,000 m), and a separate turning circle of 600 m diameter connected by the diversion channel to the main approach channel. Alternative-II with an outer breakwater on the northern side with a total length of 3,300 m (1,300 m + 2,000 m), and a separate turning circle of 600 m diameter connected by the diversion channel to the main approach channel. Both the alternatives would require reclamation between the existing and proposed breakwaters to accommodate the port handling facilities.

Mathematical model studies were carried out using MIKE 21-HD and sediment transport models to assess the changes in the coastal hydrodynamics and siltation pattern due to the proposed developments. From the studies with available data, and based on Japan International Cooperation agency report, it was found that Alternative-I layout is a better option considering both tidal hydrodynamics and sedimentation aspects as the flow is comparatively smooth and sedimentation is comparatively less. The estimated total sedimentation in the entire harbour region with Alternative-I works out to be of the order of 9 M m^3. As this study is based on the available data, a comprehensive and more detailed study is required with the latest data on bathymetry, tidal levels, currents, waves and sediment data to arrive at more realistic results.



Flow Field During Peak EBB



Sedimentation Pattern

STUDY ON THE TECHNICAL FEASIBILITY OF A PORT AT BICHITRAPUR, ORISSA

M/s JSW Infrastructure Ltd (JSWIL) proposes to develop an all-weather deep water port at Bichitrapur, Orissa about 5 km north of the mouth of the River Subarnarekha to handle import and export cargoes. CWPRS carried out mathematical modeling studies using MIKE-21 software to assess the viability of the port and to evaluate the effect of the development of the port. It was also required to determine the impact of port construction on the coastal morphology and the mouth of Subarnarekha River.

The mathematical model studies indicated that the proposed JSW Port was technically feasible with proper sand bypassing arrangements. Sediment supply by monsoon discharges of Subarnarekha River contribute about 0.5 M m^3 of sand per annum, a part of which was getting accumulated on the coast north of Subarnarekha. This sand would get trapped by the south breakwater of the JSW port, and may cause siltation of the creek mouth. Hence, creek mouth needs to be monitored continuously and maintained by dredging or sand bypassing. The proposed long navigational channel would require maintenance dredging, and this sand could be used for additional land development and beach nourishment regularly. As such, offshore dredge material disposal would come down drastically and subsequently the environmental impact on flora and fauna could be reduced. The south breakwater of the JSW port would have marginal effect, if any on the river mouth, which can be taken care by periodic dredging.

Location Map and Layout of Bichitrapur Port

DESK STUDIES FOR COASTAL PROTECTION WORK AT ALIBAG, RAIGAD

Alibag is a coastal town situated on the west coast of India in Raigad district of Maharashtra. To protect the coast on the southern side at Alibag Koliwada, a seawall with stone-filled gabions was constructed by the Harbour Engineering Division (HED), Government of Maharashtra which is performing satisfactorily. About 1.9 km beach on northern side of Alibag Koliwada is used by the tourists for recreational activities. The HED has a proposal to protect this beach from erosion along with its beautification for the use by the tourists. Out of 1.9 km of the beach, only 500 m to 600 m length is used extensively by the tourists. The recreational activities on the other stretches of the beach are limited. CWPRS carried out desk studies to evolve design of coastal protection works for 1.9 km length of the beach based on available data. The coastal protection works are divided into three stretches of the beach and recommendation were given for each of these stretches.

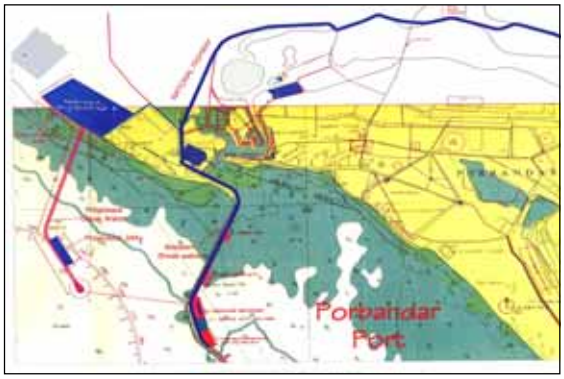
Stretch-I is the southernmost portion connected with the old gabions seawall. Since the earlier seawall with stone-filled Polypropylene (PP) rope gabions is performing well, the same was suggested for this stretch of about 200 m length. About 1,130 m long Stretch-II is the northernmost portion with the existence of rocky outcrops has limited tourist activities. A seawall with gabions containing PCC octagonal concrete block was suggested for this stretch. The design of seawall also consisted of pathway and ramps for the ease of tourists activities. The middle portion in front of Tushar Guest house for a length of about 500 m is Stretch-III, the protection works for which encompasses: i) revetment (Seawall) at the eroding coast, ii) offshore reef with sand filled geotubes, iii) groynes with sand-filled geotubes and iv) nourishment of the beach.

Location Map of Alibag Coast

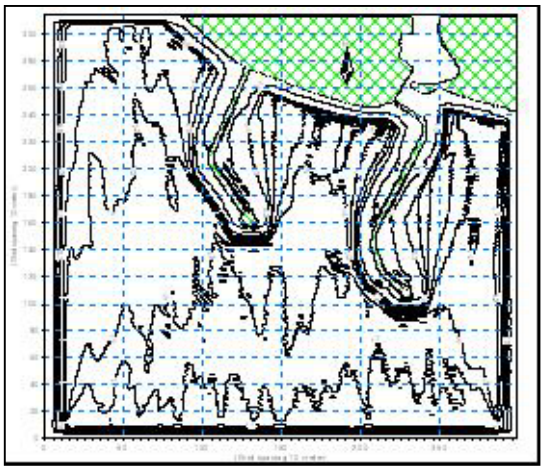
WAVE TRANQUILITY AND SILTATION STUDIES FOR DEVELOPMENT OF PORBANDER PORT, GUJARAT

The Porbandar Port is an all-weather port in Saurashtra, Gujarat, which handles large volume of cargo consisting of Coal, Bauxite, and Clinker. The harbour is protected by a rubble mound breakwater of 2,652 m length with a general cargo berth of 235 m length on its leeside. The Gujarat Maritime Board (GMB) proposes an additional breakwater of 2,060 m length and a jetty at western side of the existing breakwater to enhance the port capacity to cater to future demands. In this connection, mathematical model studies were carried out for examining the wave tranquility and tidal hydrodynamics / siltation aspects of the proposed layout.

An area of 2.5 km by 2.5 km with a grid size of 10 m in x and y direction was considered for the studies. The offshore wave data reported by India Meteorological Department as observed from ships plying in deep waters off Porbandar were transformed into near shore wave condition (-15 m depth contour) using OUTRAY model. Mathematical model studies for wave propagation were carried out using MIKE-21 BW software to examine the adequacy of the proposed breakwater layout to achieve the desired wave tranquility in the harbor area. The model was run for the wave conditions obtained from result of OUTRAY model for waves coming from South, SSW, SW, WSW and West directions. The studies indicated that the wave tranquility can be achieved with given breakwater layout for almost the entire year, except 2 to 3 days of incident waves from South and SSW direction. The proposed layout is estimated to provide 362 days of operations of container berth in a year.



Proposed Breakwater to the West of Existing One



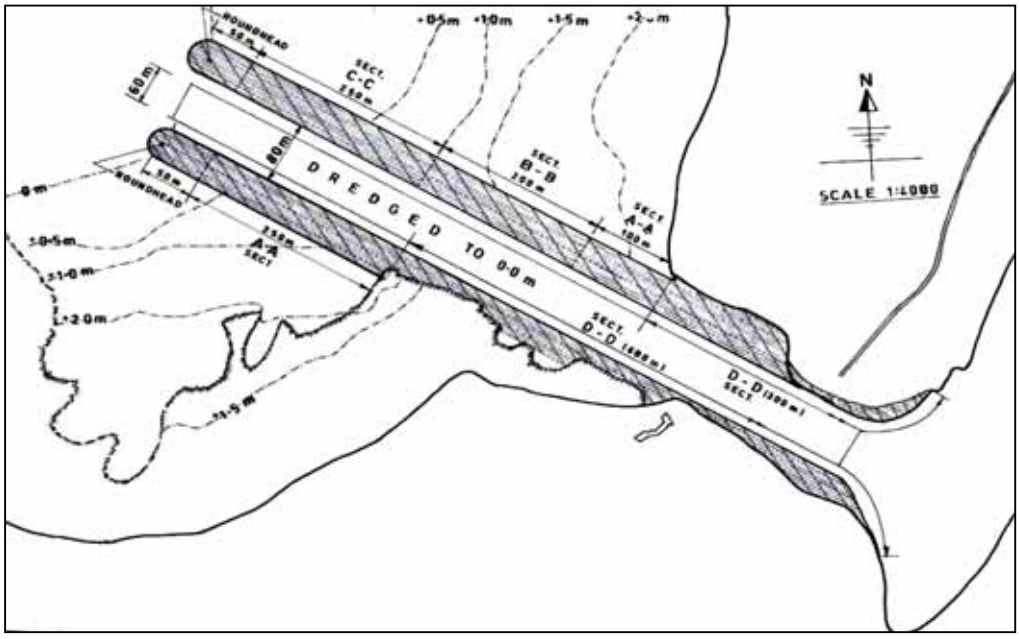
Wave Height Contours for Incident Wave Height 2 m from Southerly Direction

COASTAL AND OFFSHORE ENGINEERING
(PHYSICAL MODEL AND FIELD STUDIES)

WAVE FLUME STUDIES FOR THE DESIGN OF CROSS SECTIONS OF GROYNES AT PROPOSED NANDGAON FISHING HARBOUR, MAHARASHTRA

The Government of Maharashtra has proposed to develop a fishing harbour at Nandgaon in Raigad District of Maharashtra. Nandgaon creek has a clear width of about 100 m, and very shallow depths extending up to the tidal influence of about 2 km. Rocky outcrops exist on south side of the creek and flat beach on the north side. Sediment deposition takes place at the entrance of the creek, obstructing the movement of fishing boats due to shallow draft. The Harbour Engineering division (North), Maharashtra has proposed to construct groynes at the entrance of the creek to guide the flow and to facilitate flushing of the sediments from the creek mouth. Studies were earlier undertaken at CWPRS for alignment and design of cross-sections of the proposed groynes at the creek entrance. The hydrodynamic behavior of flow and siltation pattern was studied using mathematical model. A proposal with two parallel groynes having 300^0 N bearing and a clear spacing of 80 m, extending up to zero meter contour was suggested based on the mathematical model studies Technical Report No. 4510 . Also the bank protection along the creek has been proposed to guide the flow. It was also suggested to dredge the channel width of about 60m for two lane navigation of fishing boats up to zero meter contour for about 900 m length.

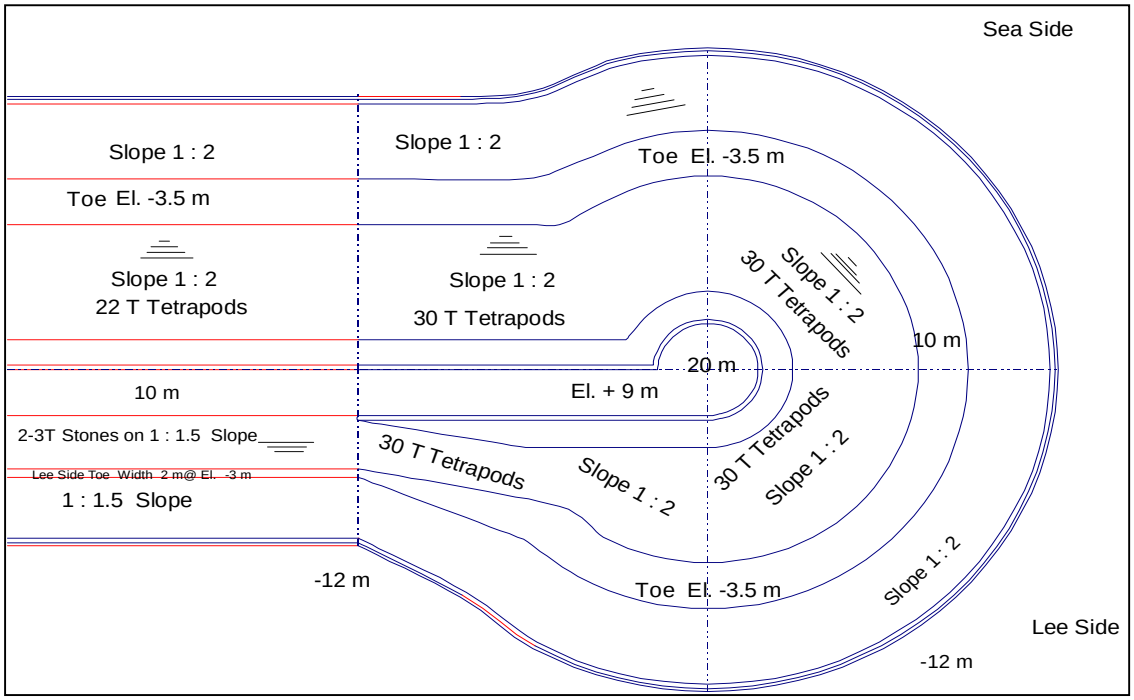
Physical model studies were conducted on 1:20 and 1:27 scale models of the groynes in a wave flume. The weight factor of 0.6678 was considered for working out the weight of stones in the model. The test section of the groyne was studied under normal attack of waves in 2-D wave flume and rounded portion was studied under angular attack of waves in 3-D diffraction basin of the wave flume for its hydraulic stability. The desk and wave flume studies helped to evolve the design of cross-sections of groynes with tetropod/ stones in the armour layer. The sections for the trunk and roundhead portion of the proposed groynes have been evolved at different bed levels as well as for the bank protection works.



Layout Plan With Groynes and Bank Protection Works at Nandgaon

WAVE FLUME STUDIES FOR DESIGN OF THE EXTENSION OF BREAKWATER AT MULDWARKA PORT, GUJARAT

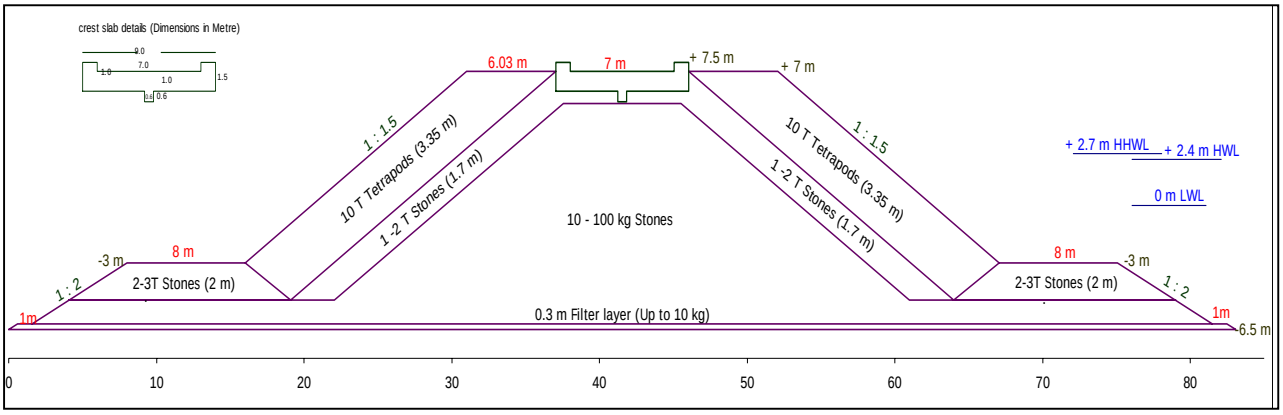
M/s Gujarat Ambuja Cements Limited (GACL) has plans to bring coal through Panamax carrier by extending the existing breakwater and jetty at Muldwarka Port in Gujarat. By considering different alternatives, the extension of the existing breakwater by 500 m was finalized through mathematical model studies. The extension of the breakwater to be constructed lies between -11 m and -13 m contour. Considering the design condition of 7.0 m waves, a cross section of rubble mound breakwater at -12.0 m bed level was worked out using 22 t tetrapods in double layer in the armour on 1:2 slopes. The roundhead of breakwater at -12 m was designed using 30 t tetrapods on 1:2 slopes in the armour. The cross section of the breakwater was studied in a wave flume to geometrically similar scale of 1:50. The studies were carried out at Low water level and High water level with regular and random wave conditions for one hour duration in the model. Both the trunk and roundhead sections were finalized for their hydraulic stability.



Plan of Roundhead (at -12 m Bed Level) and Transition to Trunk Portion of Proposed Extension of Breakwater at Muldwarka

WAVE FLUME STUDIES FOR DESIGN OF CROSS-SECTIONS OF BREAKWATER AT BUTLER BAY

The Andaman & Lakshadweep Harbour Works proposes to develop landing/berthing facilities at Butler Bay in Little Andaman. Layout of the harbour, consisting of breakwater and berthing jetty, was finalized through mathematical model studies earlier at CWPRS. Further, desk and wave flume studies were carried out to evolve the design of cross-sections of a 680 m long rubble mound breakwater. Initially, desk studies were carried out to design the cross section of the breakwater at various depths and roundhead. The model tests for the designed cross-section were carried out in a wave flume on a 1:36 scale 2D model. The trunk sections, for various reaches at +1.0 m, 0.0 m, -2.0 m and -5.0 m bed levels, evolved through wave flume studies, consist of 4 t and 8 t in the armour layer in various stretches of the breakwater. The roundhead portion of the breakwater at -6.5 m bed contour consists of 10 t tetrapods as armour on 1:1.5 slopes. It was also recommended that the tetrapods in double layer in the armour of the breakwater should be placed with packing densities of 74, 47 and 40 blocks/100 m^2 for 4 t, 8 t and 10 t tetrapods, respectively.

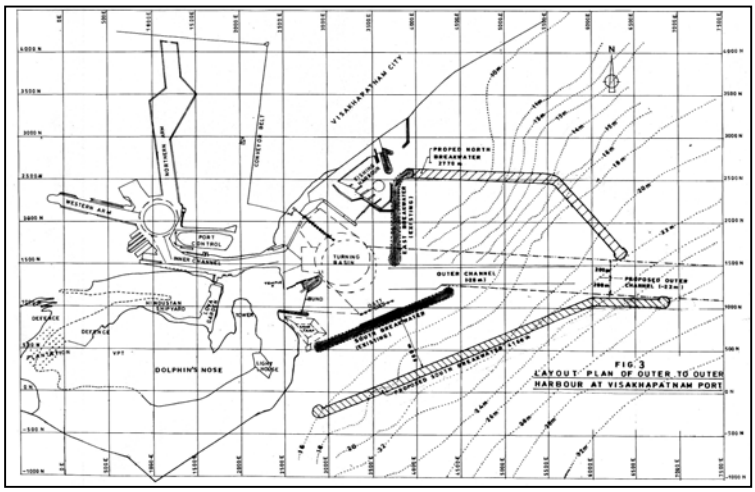


Roundhead Section of Breakwater at Butler Bay (-6.5 m)

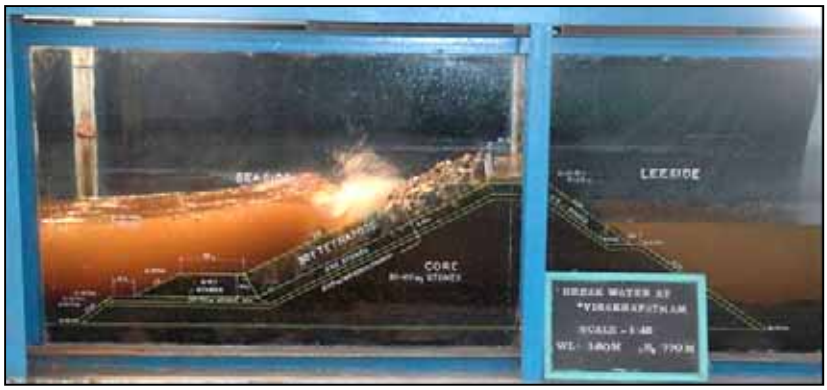
STUDIES FOR DESIGN OF BREAKWATER FOR THE DEVELOPMENT OF OUTER TO OUTER HARBOUR AT VISAKHAPATNAM

The existing Visakhapatnam Outer Harbour consists of various terminals and jetties protected by northern, southern and eastern breakwaters. Visakhapatnam Port Trust (VPT) proposes to develop an Outer to Outer Harbour to cater to future demands. In this phase of development, it is proposed to construct a south breakwater of 4,160 m length south of the existing south breakwater and a north breakwater of 2,770 m length extending from the northern tip of the existing east breakwater. CWPRS carried out various hydraulic model studies to optimize the proposed Outer to Outer Harbour.

The conceptual layout plan of the Outer to Outer Harbour proposed by VPT was optimized and confirmed through mathematical model studies. The desk and wave flume studies were also carried out for design of the cross-sections of two breakwaters. The design wave conditions for the breakwaters were derived from the results of earlier studies carried out at CWPRS. The significant wave height (Hs) of 7.6 m was considered as design wave for zero order damage. Cross-sections at various depths of water and the roundheads for both the breakwaters were initially designed using empirical methods. The trunk sections of the breakwater consisted of 20 t, 25 t and 30 t tetrapods on 1:2 slopes in the armour at various reaches. The seaward roundheads of the breakwater consist of 35 t tetrapods on 1:2 slopes in the armour layer. Both the breakwaters would be constructed in the deeper water depths of up to 30 m. The armour layer was optimized through wave flume tests on a 1:48 scale geometrically similar model. The armour was provided only up to - 8 m level. A wide toe of 10 m width has been provided at - 8 m level with 4 t to 6 t stones.



Layout Plan of Outer to Outer Harbour at Visakhapatnam Port



Wave (Hs = 7.70 m) Action on Armour Layer of Breakwater

PHYSICAL MODEL STUDIES FOR ALIGNMENT OF PROPOSED SOUTHERN OIL JETTY AT PARADIP PORT, ORISSA

The Paradip Port, which is a major port of India on the east coast of Orissa, handles vessels up to 80,000 DWT for different types of cargo. The port trust proposes to provide a new dock complex and an oil berth on the south side of the port to handle crude oil and its products. The draft at the berth will be up to -17.1m to handle 125,000 DWT capacity vessels, and later on up to -21.0 m. In order to cater for higher size vessels, it has been decided to deepen the approach channel to -18.7 m and widen it to 300 m. The approach channel is proposed to be extended up to 10 km. CWPRS carried out the hydraulic model studies to decide the alignment of the proposed oil jetty after incorporating above changes on the existing physical wave model.

The available physical model at CWPRS with a scale of 1:125 (GS) has facility to reproduce waves from the two predominant directions, viz. East-South-East and South. The studies revealed that, the wave disturbance in the proposed southern dock was negligible. The wave heights in front of the proposed oil jetty were of the order of 0.07 m to 0.1 m for external waves form East-South-East and South directions, which are much lesser than the permissible limit of 1.0 m. The wave approach angle will not cause any adverse effect on berthing vessels. Even if minor changes in the proposed alignment of the berth are made, there would not be any significant effect on the oil cargo handling. The studies indicated that the sand trap and approach channel should be maintained properly to avoid siltation problem in the turning circle and the proposed southern dock arm.

View of Paradip Port

Wave Tranquility Inside the Proposed Southern Dock During Waves from South Direction

ANALYSIS OF HYDROGRAPHIC SURVEY DATA FOR MORPHOLOGICAL CHANGES AROUND SOGAL CHANNEL IN THE APPROACHES TO KANDLA PORT

Kandla Port is a major all-weather port, located in Gulf of Kutch on the west coast of India in Gujarat. The port was developed along the west bank of Kandla creek by reclaiming inter tidal flats. The approach to the Kandla creek is along a 17 km long navigational channel, known as Sogal channel. The Sogal channel at Kandla port, however, is required to be maintained by regular dredging for a length of about 4,500 m. Since 2006, Kandla Port is awarding the dredging contract on assured depth concept. Regular hydrographic survey data of the channel is analyzed by CWPRS to assess the siltation pattern along the channel due to deepening of the channel.

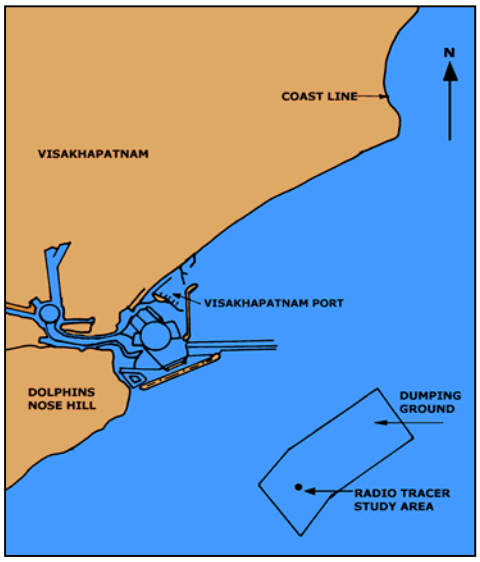
Based on the analysis it was found that from February 2006 to October 2009, the depths along the channel have improved in phases from -6.5 m to -8.3 m w.r.t. chart datum (CD) The average annual maintenance dredging is about 7.0 M m^3 to maintain a depth of 8.0 m along the navigational channel. Analysis of relevant data indicated that as the depth increased along the channel, the rate of siltation had also increased. The major part of maintenance dredging was carried out in the southern reach of the channel. Concentration of dredging in the southern portion, and not deploying the dredger effectively in the other reaches, has led to encroachment of the west bank into the channel. The analysis of the hydrographic surveys would be useful for the future planning of the Kandla Port.

Location Map of Kandla Port

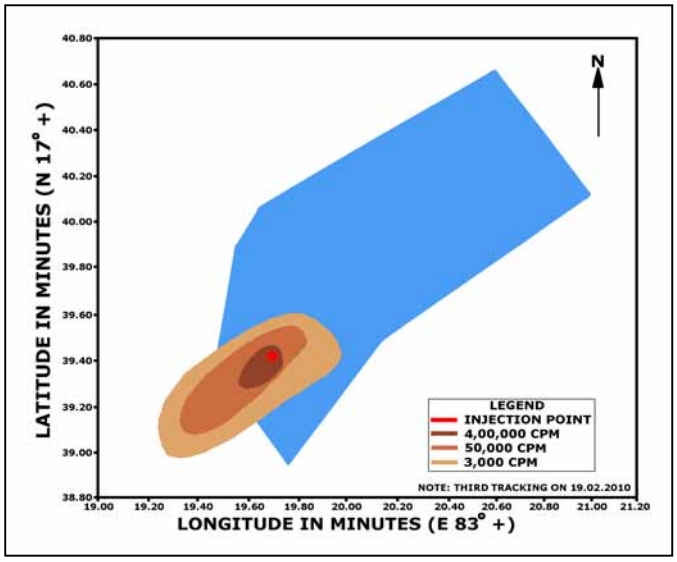
RADIO ACTIVE TRACER STUDIES AT VISAKHAPATNAM PORT, ANDHRA PRADESH

Visakhapatnam Port Trust (VPT) is contemplating to develop three berths in the Northern arm of Inner Harbour. Environmental clearance for the project necessitated assessment of the movement of the dumping of the dredged spoil from the inner harbour. CWPRS and Bhabha Atomic Research Centre (BARC) jointly conducted the Radio-Active Tracer (RAT) studies to assess the behavior of the existing dumping ground and thereby to assess its suitability.

The existing dumping ground which is at -35 m contour is being used to dump the dredged spoil resulting from the annual capital and maintenance dredging activities. Since most of the maintenance dredging activity is carried out during January-April, which is a calmer period, the same was chosen for conducting the tracer study. The study was conducted by injecting the RAT Scandium-46, with a half–life period of 84 days. The post injection tracking of the tracer from three surveys, spanning a period of about three months, indicated that predominant movement of the bed material is towards South-West direction. At the end of 74 days, the maximum longitudinal and transverse spread of the sediment was found to be about 1,200 m and 340 m, respectively. The average velocity of sediment transport over the study period was found to be 15 m/day. Based on RAT investigations, it was inferred that the dumping site is suitable for disposal of the dredged material during the months January-April, and the movement of sediment would be away from the shipping channel.



Dumping Ground Location of Visakhapatnam Port



Spreading Pattern of Radio-Active Tracer

STUDIES FOR DESIGN OF BREAKWATER FOR DEVELOPMENT OF SHIP BUILDING YARD NEAR CUDDALORE, TAMIL NADU

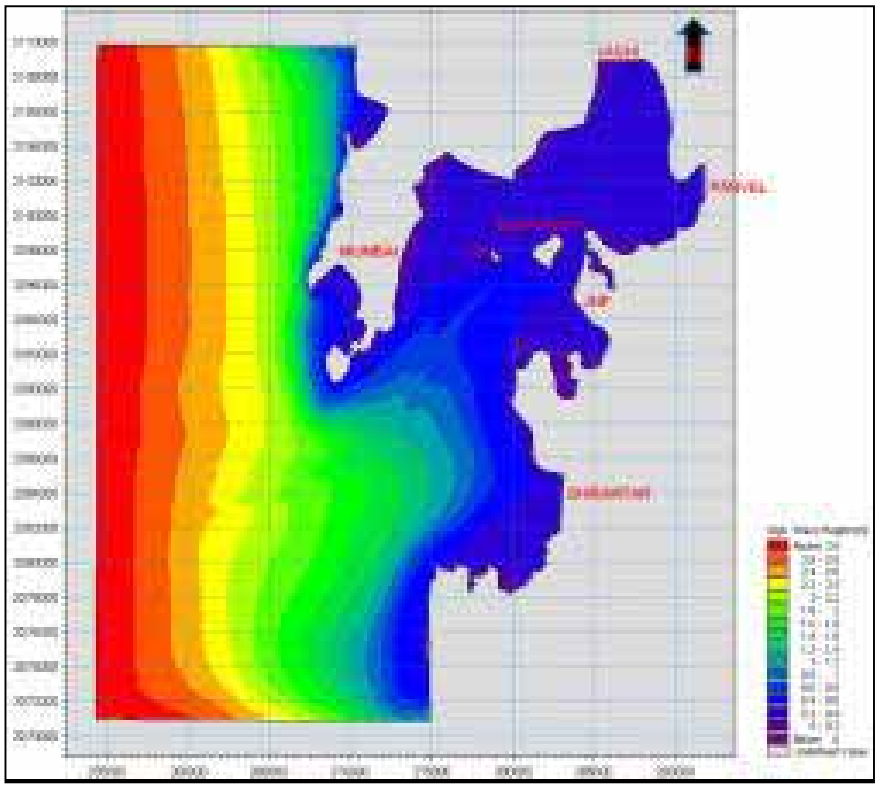
M/s Goodearth Ship-building Private Limited proposes to develop a shipbuilding yard near Cuddlore, Tamil Nadu. The harbour layout of the shipbuilding yard consists of 2,100 m long south breakwater and 875 m long north breakwater. Phase I of the project consists of construction of 1,100 m length of south breakwater and 300 m long jetty structure on the north side. Breakwater cross-sections at various water depths were evolved through desk and wave flume studies. Tidal levels reported in the Indian Tide Tables were considered for the design of breakwater cross-sections. The 50-year return period significant wave height of 7.0 m used for the design of breakwater was obtained from the extreme value analysis of hindcast storm wave data. Hydraulic model studies for the designed trunk sections at -8.5 m bed level was carried out in the wave flume on a 1:43 scale 2-D model and the round head portion was studied for its hydraulic stability under angular attack of waves on a 1:48 scale 3-D model. The recommended trunk section at - 8.5 m bed level consists of 15 t tetrapods on 1:2 slope in the armour, whereas the roundhead at - 9.0 m bed level consists of 20 t tetrapods on 1:2 slope in the armour. The cross sections were observed to be stable under the design wave conditions.

Testing Roundhead in Diffraction Basin of Wave Flume

STUDIES FOR DEVELOPMENT OF FIFTH OIL BERTH AT JAWAHAR DWEEP TERMINAL

The Mumbai Port (MbP), a major port on the west coast, is a natural harbour having its main navigational channel shared by MbP and Jawaharlal Nehru Port up to Jawahar Dweep Terminal. Under its expansion plan, MbP has a proposal to develop Vth oil berth near Jawahar Dweep to handle oil tankers of type Suez Max laden (125,000 DWT). Field data collection and physical model studies were carried out at CWPRS to finalize the orientation and location of fifth oil berth with proposed reclamation.

Field studies were carried out to measure water levels, current and silt charge at proposed location of fifth oil berth. The data collected indicates that maximum strength of current during flood is 1.05 m/s and ebb is 0.56 m/s. The average direction of flood is about 55^0 N, while during the ebb, direction varies between 210^0 N and 278^0 N indicating formation of small eddy and considerable reduction in strength of current. These field data were used to calibrate the flow conditions in the physical model. Physical model studies were carried out on the existing tidal model of Mumbai Port having scale 1:400 (horizontal) and 1:80 (vertical). Based on these studies, the alignment of the proposed Vth oil berth in line with the existing IVth oil berth along the navigational channel was found suitable from hydrodynamic consideration. The proposed reclamation of 24 Ha at Jawahar Dweep does not affect flow conditions at the existing J-1 to J-4 berths as well as at the proposed J-5 berth. Since the jetty head and approach trestle are to be built on piles, there will be no disturbance to the prevailing flow pattern.



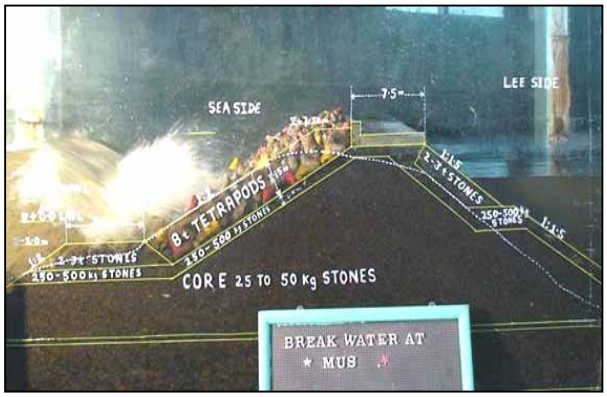
Typical Model Run Results Showing Wave Height

STUDIES FOR RESTORATION OF DAMAGED BREAKWATER AT MUS HARBOUR, CAR NICOBAR ISLAND

The Andaman and Lakshadweep Harbour Works (ALHW) have developed a harbour facility at Mus, Car Nicobar consisting of a 490 m long breakwater to cater for the inter-island ships. The existing breakwater at Mus harbour suffered severe damage to the armour in June 2007 due to severe wave climate. Higher waves attacked the existing breakwater due to increase in the relative water depth caused by subsidence of land mass during the Sumatra earthquake of 26 Dec 2004.

The restoration sections for the breakwater were evolved by CWPRS at various chainages based on empirical formulae. Desk and wave flume studies were conducted to check the hydraulic stability of the restoration sections under the attack of design wave conditions. The model tests were carried out in a random sea wave flume with Geometrically Similar (GS) model scale of 1:36 for the trunk section of break water. The relative increase in the water depth in post-tsunami scenario was also considered.

The ALHW have proposed to further expand the harbour facility for which the existing 490 m long breakwater is proposed to be extended by 500 m between -11 m and -18 m depth contours. Design wave conditions for the breakwater were considered as: a) 5.0 m waves for zero order (0 -1%) damage, and b) 6.0 m waves for first order (1-5%) damage. Desk and wave flume studies were conducted to design trunk and roundhead sections of the extension of breakwater. A cross section of breakwater at -14.0 m bed level has been evolved using 8 t tetrapods in double layer in the armour on 1:2 slope. The roundhead of breakwater at EL -18 m has been designed using 10 t tetrapods on 1:2 slope in the armour. Both the trunk and roundhead sections were finalized through hydraulic model tests in a wave flume on a 1:36 scale geometrically similar model to ensure their stability.



Testing of Restored Breakwater Section in Random Wave Flume

Wave Attack on Roundhead Portion of Breakwater in 3-D Diffraction Basin

DESIGN OF CROSS-SECTIONS OF BREAKWATERS FOR DEVELOPMENT OF FISHERIES HARBOR AT GANGOLLI, KARNATAKA

Gangolli Fisheries harbour is located on the west coast of India in Udupi District of Karnataka. The bay has the confluence of 5 rivers forming Pancha Gangavali, before meeting the Arabian Sea. The main restriction at this port is the recurrence of sand bar at the mouth / gut more particularly on the north bank. Fishermen are facing difficulty in navigating the vessels due to narrow entrance and shallow depths at the mouth. Mathematical model studies carried out earlier to finalize the length and alignment of two parallel breakwaters at the entrance for guiding the flow and maintain the depths for navigation of fishing vessels. The desk and wave flume studies have been carried out to evolve the design of cross-sections of the bank protection and breakwaters at various bed levels.

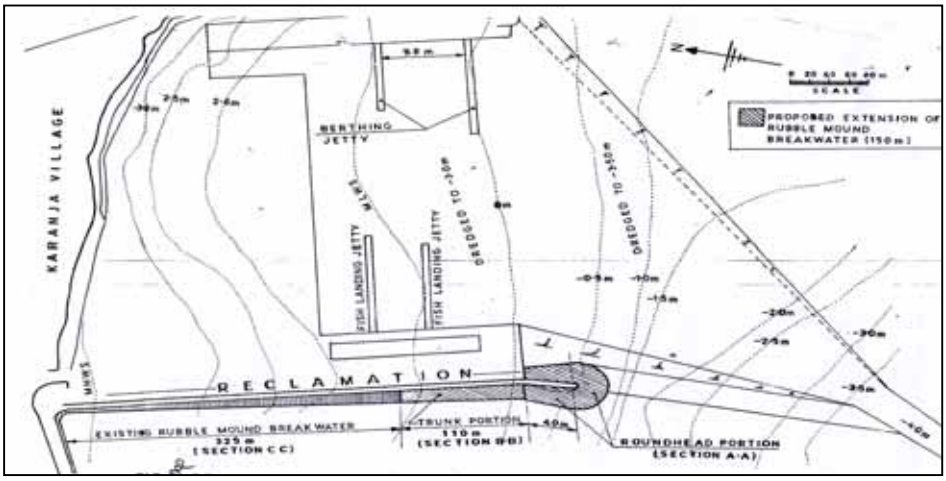
The sections for the trunk and roundhead portion of the breakwater at various bed levels have been evolved through wave flume studies on a 1:27 Geometrically Similar model. The trunk sections of the breakwater consist of 3t and 5t tetrapods on 1:2 slopes in the armour at various reaches. The roundheads consist of 2 to 3 t tetrapods on 1:2 slopes in the armour layer. The cross-sections of bank protection consist of 0.5t to 1t stones in the armour with 1:2 slopes. The channel in between the breakwaters is to be dredged upto -5 m bed level. It was found that these sections were under the design wave conditions.

Design of Breakwaters for Fishery Harbour at Gangolli, Karnataka

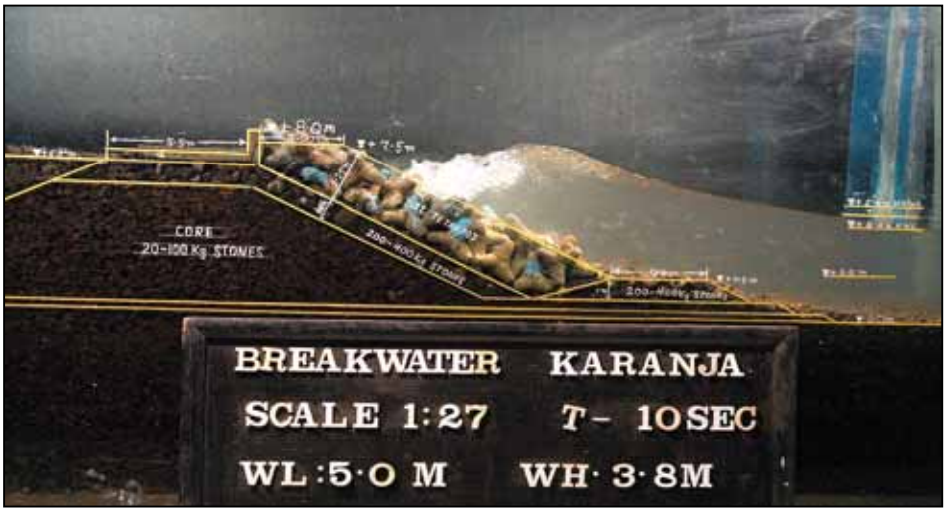
STUDIES FOR DESIGN OF BREAKWATER FOR DEVELOPMENT OF FISHERIES HARBOR AT KARANJA

A fisheries harbour is proposed to be developed at Karanja in Darmatar Creek on the west coast of India in Raigad district of Maharashtra by extending the existing 325 m long bund / breakwater. Studies have already been carried out in respect of wave tranquility, tidal flow conditions and sediment movement at the proposed harbour area to assess feasibility of layout and to suggest suitable modifications. Flow condition in the approach channel as well as inside the harbour area were found satisfactory for 150 m extension of the existing breakwater, and will not affect the safe berthing of vessels.

Desk and wave flume studies have been now carried out for the design of cross-sections of breakwater at various bed levels. The entire breakwater length of 475 m falls in shallow depths of water. The tip of the breakwater is at about the lowest low water level. As such, the sections of breakwater were designed to withstand the breaking wave conditions at the respective bed levels. For the root portion of about 325 m length, strengthening of the existing bund was suggested by providing 2 t tetrapods in the armour layer on seaside. Further extension of the breakwater of the 110 m length was suggested with 3 t tetrapods in the armour on seaside, whereas 4 t tetrapods in the armour on both the sides were suggested for the 40 m long end portion (roundhead) of the breakwater.



Proposed Layout of Karanja Fisheries Harbour



Wave Action at Breakwater During Flume Studies

FOUNDATION AND STRUCTURES

ASSESSING QUALITY OF CONCRETE OF LONI SAVANGI, MANGRUL AND RAJA TAKLI BARRAGES ACROSS RIVER GODAVARI

Loni Savangi, Mangrul and Raja Takli barrages are constructed across river Godavari in Jalna District, Maharasthra. These barrages are constructed using mass concrete mix having cement level of 330 kg/m^3 and maximum size of aggregates 80 mm. The barrages would store about 80 Mm^3 of water at FRL, facilitating additional supply of water for irrigation. CWPRS assessed the quality of concrete of the three barrages by extracting cores from different locations.

In all 13 cores of diameter 100 mm and 150 mm upto a length of about 400 mm. were extracted from different locations of these three barrages. These cores were dressed suitably and tested to determine Dynamic Modulus of Elasticity by using a resonant frequency apparatus. The cores were cut to appropriate length (l/d = 2), capped suitably and tested for estimating compressive strength and static modulus of elasticity using a uniaxial compression testing machine of capacity 200 T/60 T. The results of the tests conducted are given in the table below:

Sl. No.	Barrage	Compressive Strength(kg/cm^2)	Static modulus of elasticity(kg/cm^2)	Dynamic modulus of elasticity(kg/cm^2)
1	Mangrul	201.6 - 240.2	1.94 x 10^5 - 2.04 x 10^5	2.64 x 10^5 - 2.78 x 10^5
2	Loni Savangi	191.0 - 210.1	1.42 x 10^5 - 1.57 x 10^5	2.00 x 10^5 - 2.11 x 10^5
3	Raja Takli	185.5 - 298.9	1.77 x 10^5 - 2.10 x 10^5	1.97 x 10^5 - 2.75 x 10^5

The results indicated a fairly good agreement between the designed value of the concrete mix namely M-15 grade and core strength values. Also, the visual inspection of the cores indicated the degree of compaction of concrete as good.

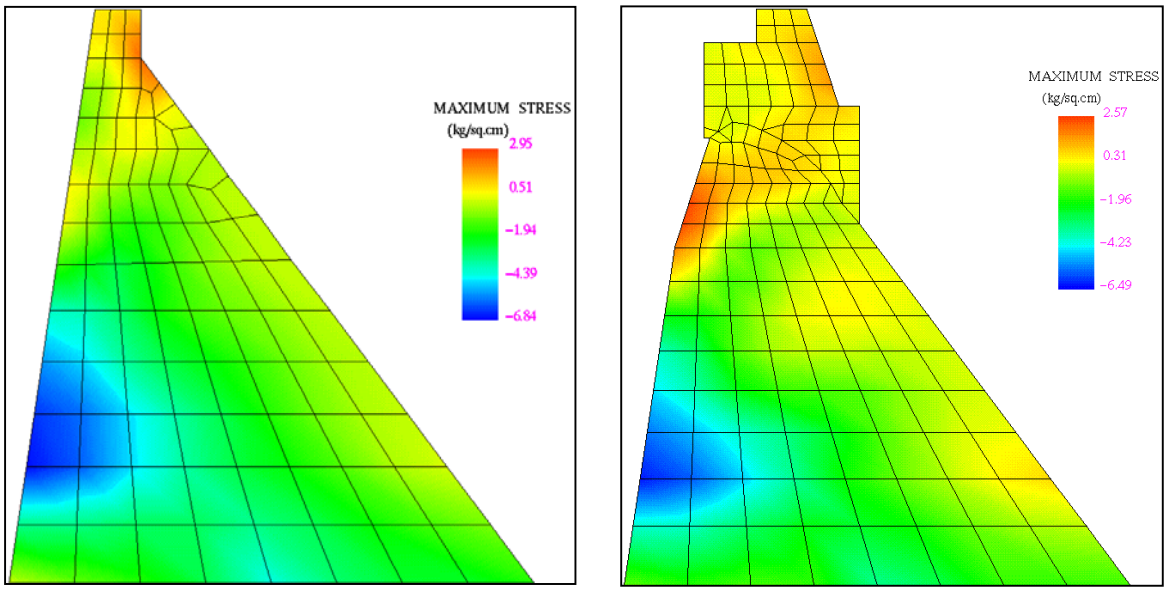
Core Drilling in Progress

Test Setup for Determination of Dynamic Modulus of Elasticity

DYNAMIC RESPONSE ANALYSIS FOR ASSESSING THE SEISMIC STABILITY OF MIDDLE VAITARANA DAM

The Middle Baitarana Dam Project in the Sahyadri hill range of Maharashtra state envisages construction of a 99.5 m high and 550 m long roller compacted concrete gravity dam with a live storage of 202 Mm^3. The dam site is located at Latitude 19.70° N and Longitude 73.43°E between Upper Vaitarna Project on the upstream and Modak Sagar on the downstream side. The dam site lies in the deccan trap province, which witnessed the great Koyna earthquake of 1967 with magnitude 6.5. The dam site lies in Zone-III as per the seismic zoning map of India given in BIS-1893 (Part 1): 2002. To assess the seismic stability of the Middle Vaitarna dam, detailed dynamic response analysis of the tallest non-overflow and overflow sections has been carried out using site-specific design accelerogram evaluated by IIT, Roorkee.

The response analysis was based on the sub-structure approach, wherein the reservoir and foundation rock domains are first analyzed separately as continua to obtain the hydrodynamic and dam foundation rock interaction forces, respectively. The dam sections are then analyzed by a two-dimensional finite element idealization with the earthquake and interaction forces acting externally. To assess the safety of the dam, the stresses are estimated due to the combined effect of the dynamic and various static forces like self-weight, hydrostatic pressure and the uplift pressure. The maximum values of the compressive and tensile stresses for non-overflow section are found to be 37.22 kg/cm^2 and 2.95 kg/cm^2, respectively. The corresponding values for the overflow section were found to be 36.55 kg/cm^2 and 2.57 kg/cm^2, respectively. All the induced stress values are well within the design strength corrected for the dynamic effects and the non-linear behaviour. Both the non-overflow and overflow sections of the dam are thus considered to be safe under the given earthquake forces in combination with the possible static loads.



Distribution of Maximum Principal Stresses in Non-overflow and Overflow Sections of Middle Vaitarna Dam

METHODOLOGIES FOR UNDERWATER REPAIRS TO UKAI LEFT BANK MAIN CANAL

The 4,400 m long, Ukai left bank main canal taking off from Ukai dam fetches water to the 840 MW thermal power station run by the Gujarat State Electricity Corporation Limited (GSECL). The canal was constructed in 1972-73 mainly on embankment, partially on cut and fill and partially in cut. Lining of the canal was done using pre-cast cement concrete panels. Due to ageing of concrete and continuous flow of water, these concrete panels have been severely damaged at many places. Many panels have settled down and cracked. Deep potholes exposing earth are also found in the panels. The canal crosses Ghodakhadi nallah at chainage 4,080 m where a 60 m long rectangular aqueduct of size 5.0 m x 3.2 m is constructed. The masonry wing walls at canal-aqueduct joints show heavy seepage of water through the canal. The embankment has eroded considerably at some sections which could lead to breaching of canal.

Suitable methodologies for repair and strengthening of the canal have been suggested based on the past experience. Immediate strengthening at chainage 2,250 m was required where the canal is likely to breach. Due to continuous power generation, the canal is in operation to its full capacity all the time. The repair work therefore had to be undertaken in underwater condition only. Methods such as Grouted mattress technique, placing of stone filled gabions, providing pre-cast concrete lining sections were suggested for rehabilitation of canal lining under condition of flowing water. Grouting techniques for strengthening the embankment at weak portions and at junctions of canal and aqueduct were also suggested.

Damages in the Embankment

Grouted Mattress Lining

STUDIES ON POLYMER BASED IRONITE CERAMIC MATERIAL TO REPAIR DAMAGES OF SALAULI DAM, GOA

The Salauli Dam across river Salauli, a tributary of river Zuari, is a composite dam consisting of a central masonry spillway in river gorge portion and earthen portions on both sides. The spillway consists of U/s Duck Bill Spillway Wall & trough for energy dissipation, hump weir with spillway glacis connected to the downstream stilling basin arrangements. Two baffle blocks, each of size 5 m x 5 m x 2.4 m are provided in stilling basin for dissipation of energy.

Due to passage of high flood of magnitude 510 m^3/s during 2008, the spillway and the stilling basin of the dam including the baffle blocks got damaged. These damages were to be repaired using Polymer based Ironite Ceramic material. CWPRS assessed the strength and other properties of the mortar and slurry as per the relevant standards (BIS / ASTM / ACI). The compressive strength, flexural strength, the tensile strain capacity and the abrasion resistance were found to be 600 kg/cm^2, 48 kg/cm^2, 149 x 10^{-6} & 0.33 gm/cm^2 respectively for the mortar mix and 400 kg/cm^2, 44 kg/cm^2, 112 x 10^{-6} & 0.29 gm/cm^2 respectively for the slurry mix. The bond strength for mortar & slurry with concrete for one primer was indicated to be 16 kg/cm^2 & 14.5 kg/cm^2 respectively and for the second primer as 17.5 kg/cm^2 & 16.5 Kg/cm^2 respectively. The Polymer based Ironite Ceramic material in combination with cement exhibited relatively good strength and bonding properties making it suitable for repairing damages in the Salauli Dam. Since the primary constituents of the Ironite ceramic and cement are in their natural form, the material is expected to perform well for longer periods.

Duckbill Spillway

Baffle Blocks in Stilling Basin

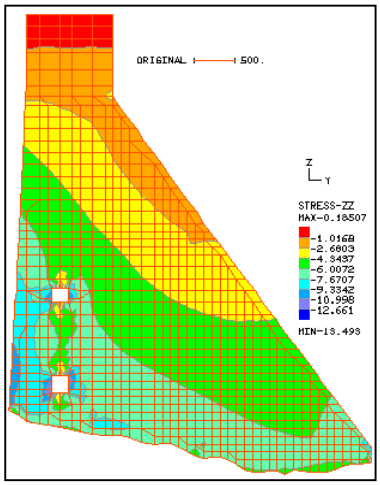
Damages in Baffle Blocks

ANALYSIS AND INTERPRETATION OF DAM INSTRUMENTATION DATA FOR NON OVERFLOW BLOCK 25 OF INDIRA SAGAR DAM JAN 2008 TO DEC 2009

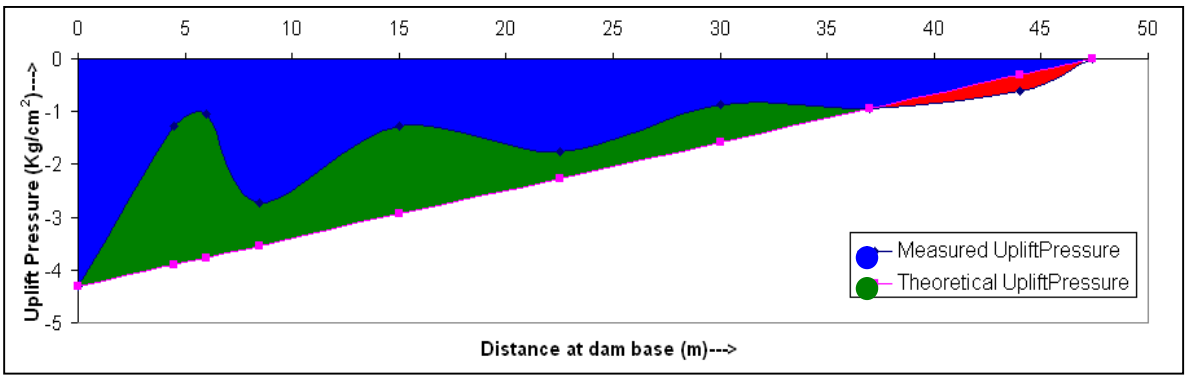
Indira Sagar dam is a concrete gravity dam across River Narmada in Madhya Pradesh. The 92-meter high, 653 m long dam consists of 27 blocks, of which block Nos. 1 to 3 and 25 to 27 are non-overflow type whereas blocks 4 to 24 form overflow spillway portion. To monitor the structural behaviour of the dam, various kinds of instruments such as Foundation Piezometers, Pore Pressure Cells, Joint Meters. Extensometers, Reservoir Water Level Meter, Stress Meters, Strain Meters, Thermometer, etc. are installed in Non Overflow Block No. 25 at different levels and varying distances from dam axis.

The reservoir was filled for the first time in December 2003. Detailed analysis of various parameters from January 2003 to December 2009 with respect to time and water level, surface contours showing temperature distribution in dam body, uplift pressures, 2D stress analysis by FEM for various load combinations, and comparison of present results with those from previous years and also with design/ theoretical values was done. The analysis indicates that the measured uplift pressure continues to exceed theoretically computed values in downstream portion and needs attention. The pattern of measured vertical stress is in fair agreement with stress values calculated by FEM. For other parameters such as strain, temperature, and relative deformation of block joints, most of the instruments exhibited cyclic trend indicating regular dam behavior and remains within allowable limits and fairly match with the theoretical values.

Aerial View of Dam



Vertical Stress Distribution by 2D FEM



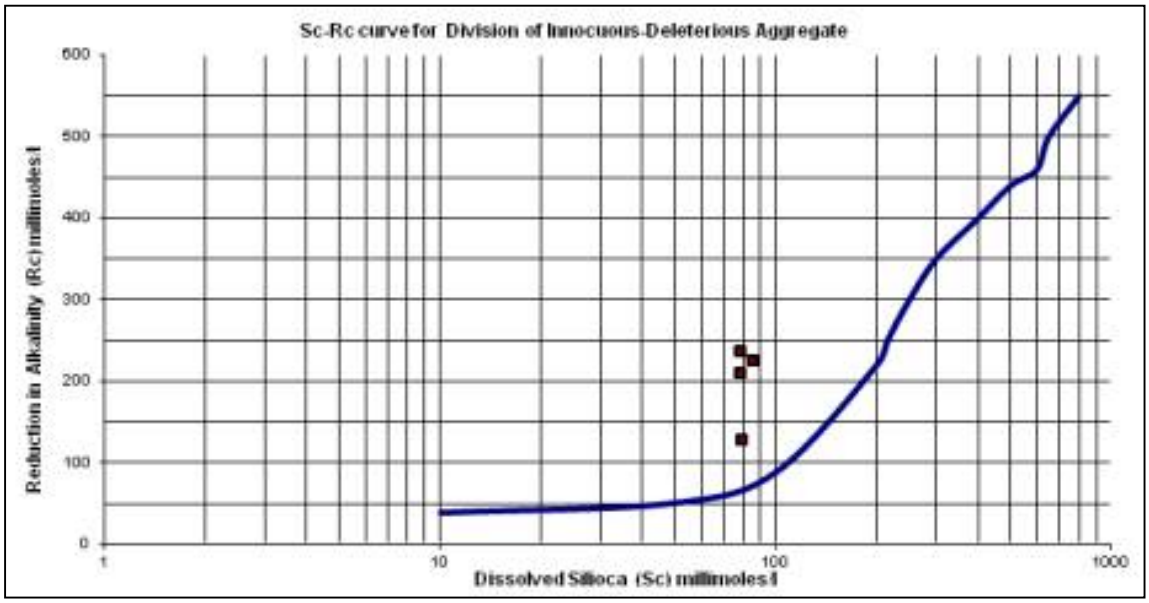
Comparison of Measured and Theoretical Uplift Pressure at Dam Base

TESTING OF ROCK SAMPLES FROM KOYNA HE PROJECT AREA FOR ALKALI-AGGREGATE REACTIVITY

One of the major factors contributing to the quality of concrete is the quality of aggregates used. Alkali aggregate reactivity test is used to determine the potential reactivity of an aggregate with alkali in Portland cement concrete. This is quantified by the amount of reaction between the standard (1-Normal) sodium hydroxide solution and the crushed aggregate where kept at 80^{o} C for 24 hours.

Alkali-aggregate reactivity was estimated for four Breccia rock samples taken from the tunnel connecting Additional Surge Gallery and the Head Race Tunnel of Koyna Hydroelectric project Stage IV. From the alkali extract of rock samples, the concentration of dissolved silica and the extent of alkali used to do so were determined following standard methods as per ASTM C-289. A point is obtained for a test sample in the standard graph in this method, which divides the zones of innocuous and deleterious aggregates. This point is related with performance of aggregate in structures.

The results of the study indicated innocuous nature of all the four Breccia rock samples, with reference to the standard curve referred in ASTM C-289, indicating less than 0.1 percent mortar expansion in a year.



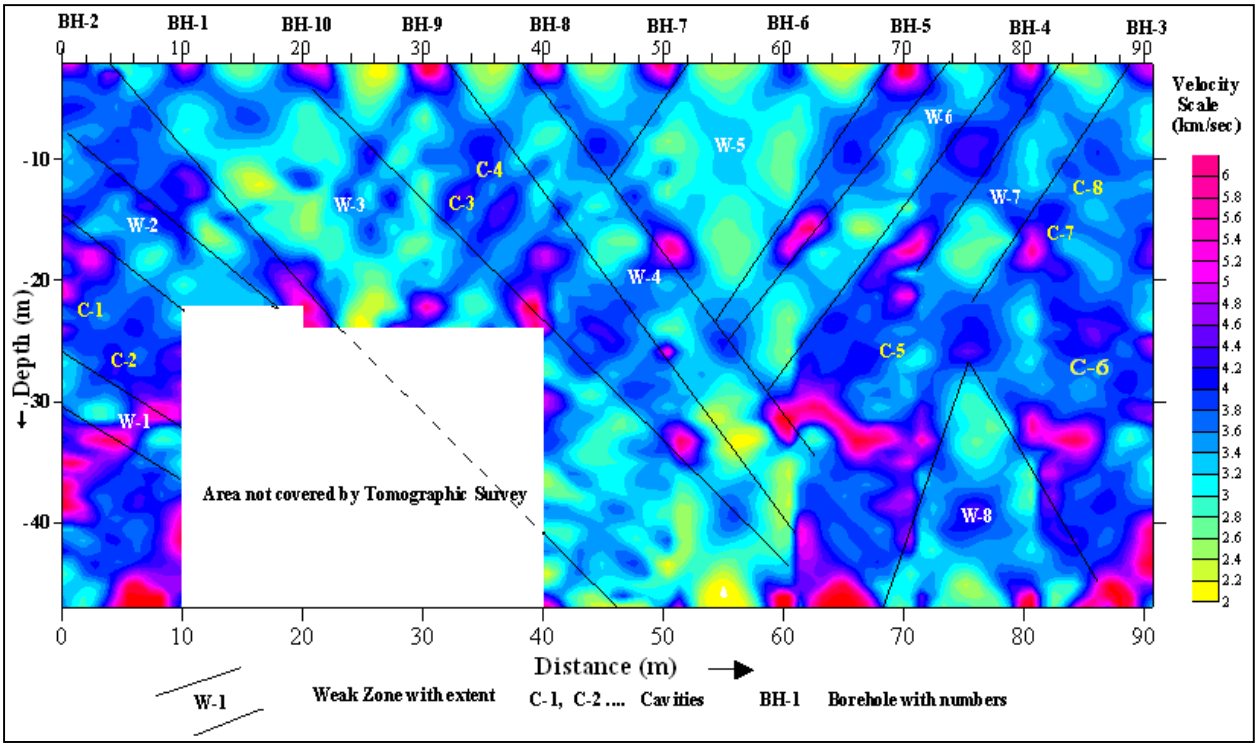
Alkali-Aggregate Reactivity Test Results Compared With Standard Curve

APPLIED EARTH SCIENCES

TOMOGRAPHIC STUDIES TO ASSESS THE SUITABILITY OF POWER HOUSE SITE AT VISHNUGAD PIPALKOTI HYDROELECTRIC PROJECT, UTTARAKHAND

The Vishnugad Pipalkoti Hydroelectric Project (VPHEP) on river Alaknanda, envisages the construction of a 65 m high dam near village Helong in Chamoli district of Uttarakhand and an underground power house with 444 MW capacity near village Hut, 20 km downstream of head works. The selected powerhouse site is located in the dolomite/slate type of rock. Tomographic studies were undertaken to evaluate the in-situ rock quality with depth for assessing the suitability of the power house site. For this purpose, 24-channel signal enhancement seismograph, borehole hammer with hydraulic clamping device and hydrophone string having 8 hydrophones at 1m interval were used in ten NX (inner dia. 76 mm) size rotary drill holes placed 10 m apart.

The velocity distribution between each consecutive pair of holes was computed using Simultaneous Iterative Reconstruction Technique. The estimated P wave velocities were correlated with the quality of rock on the basis of the ultrasonic testing of core samples collected at the site. P-wave velocities of good quality dolomite/slate rock varied between 3500 and 6000 m/sec. Eight weak zones having lower compressional velocities of 2000 -3500 m/sec and eight cavities characterized by very small size low velocity zones surrounded with high velocity zone, were inferred at different depths in a longitudinal stretch of 90 m. The above observations indicated that the selected site would be suitable for the power house after the treatment of the weak zones and cavities.



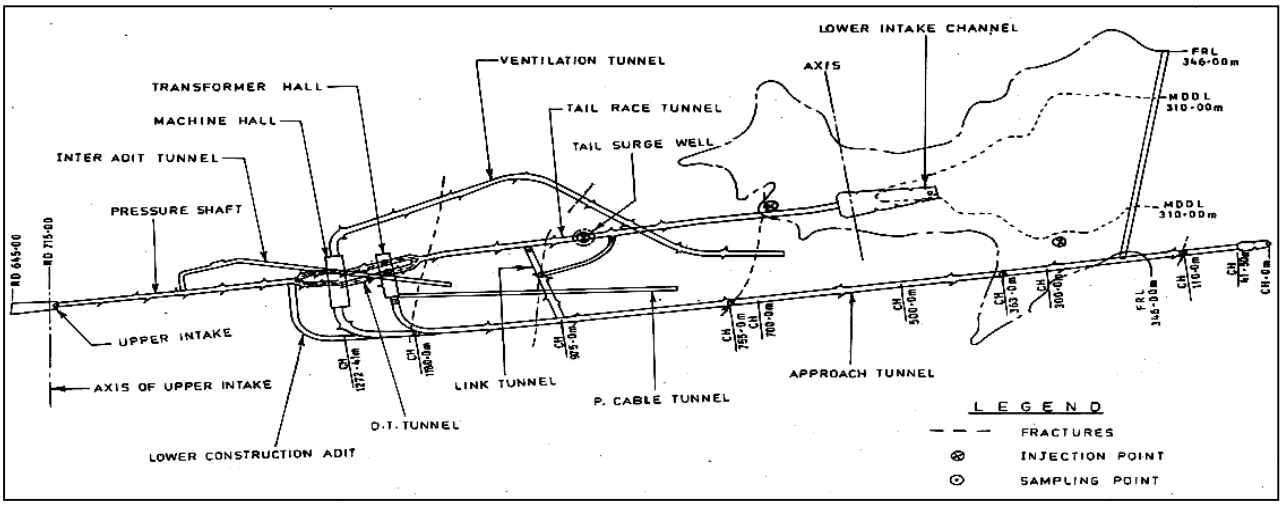
P-wave Velocities Contours Obtained Using Tomographic Analysis

TRACER STUDIES FOR DETECTING LEAKAGE IN THE APPROACH TUNNEL OF UNDERGROUND POWER HOUSE AT GHATGHAR HE PROJECT, MAHARASHTRA

Ghatghar Hydroelectric Project, comprises two reservoirs; one at an elevation of 757.50 m, formed due to an upper dam at Ghatghar and the other at an elevation of 348 m, formed due to a lower dam at Chonde village. There is an underground power house with installed capacity of 250 MW, the Tail Race Tunnel (TRT) of which joins the lower reservoir. During 2006 monsoon, when storage reached the FRL in the lower reservoir, heavy seepage was noticed at several locations inside the Approach Tunnel (AT) to the power house as well as in the power house. There was an apprehension that the leakage water might be originating from the lower reservoir and /or the TRT.

Tracer studies were undertaken by injecting sodium flouroscein dye in TRT and the lower reservoir and monitoring its arrival at leakage points for establishing interconnection, if any with (i) Tail Race Tunnel (TRT), (ii) reservoir at TRT and (iii) reservoir at MDDL.

The interconnection between reservoir or TRT and seepage in the approach tunnel could not be established. However, the leakage in the power house was revealed to be from the TRT. It was therefore recommended to divert the flow away from the power house and carry out suitable repair work of TRT during lean period of power generation.

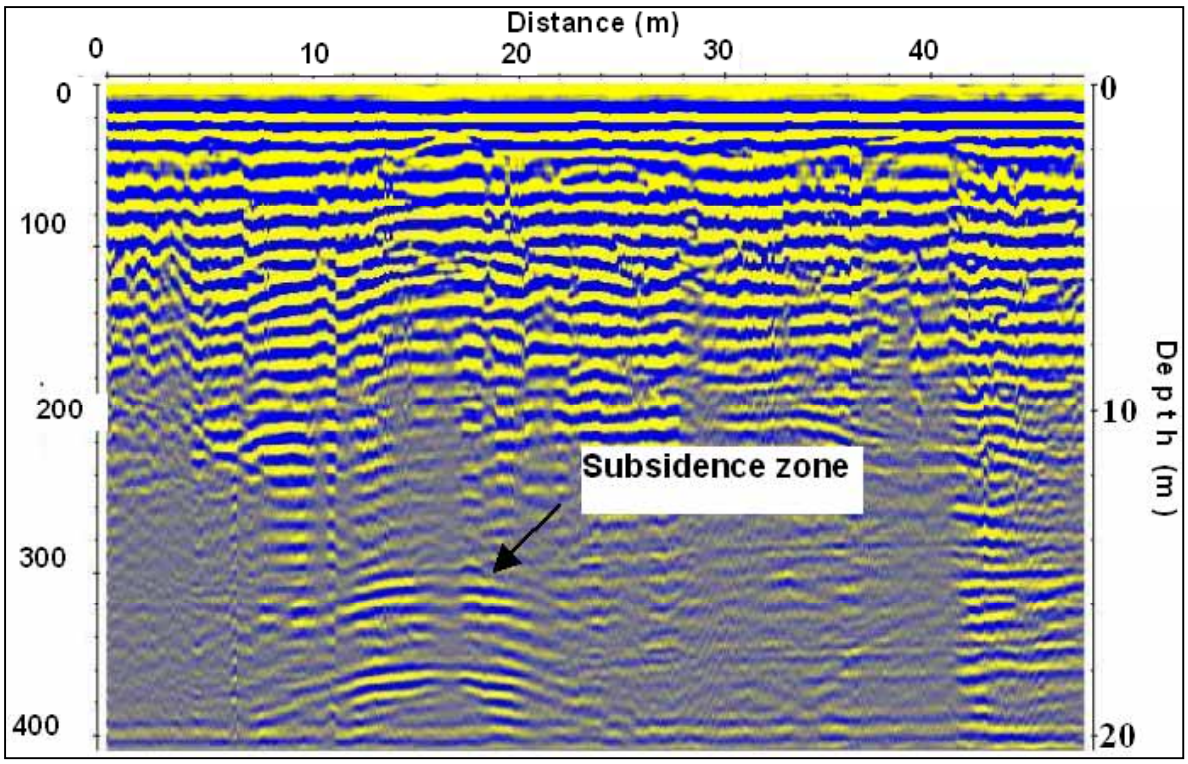


Layout of Ghatghar Pumped Storage Scheme Showing Details of Tracer Studies

GROUND PENETRATING RADAR STUDIES FOR LOCATING HIDDEN CAVITIES IN THE TUNNEL OVERBURDEN, UDHAMPUR-KATRA RAIL SECTION, J&K

During excavation of tunnel T-3 for Udhampur-Katra section of the proposed Jammu – Srinagar railway line, two huge cavities were encountered in the base of the tunnel. About 500 m of the central portion of the tunnel is passing through the aquifer of an old buried channel. It was suspected that cavities may also exist in the overburden in this portion. To locate such hidden cavities, if any, Ground Penetrating Radar (GPR) studies were conducted on the ground along and across the tunnel alignment to investigate the uppermost 20 m of the strata.

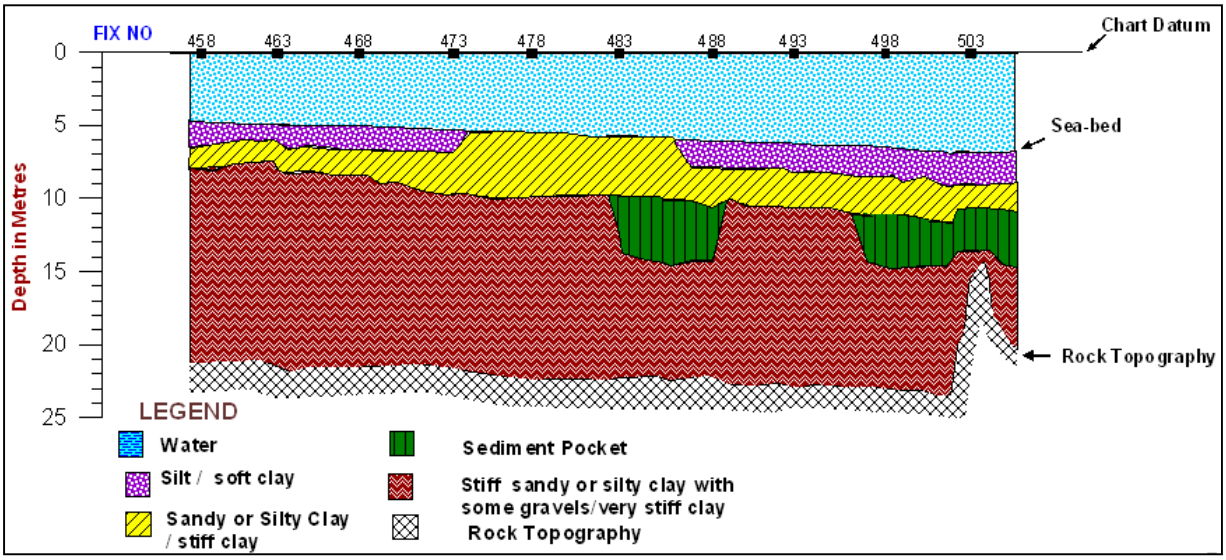
GPR data were acquired by deploying a RAMAC GPR system equipped with ProEx control unit and 100 MHz shielded antenna, manufactured by M/s MALA Geoscience, Sweden. The survey was conducted along 43 different profiles of varying lengths. The GPR was operated in distance mode with triggering interval of 10 cm to achieve higher spatial resolution. The data was processed to improve signal-to-noise ratio, thus enhancing the true anomalies. The study revealed ten anomalies in the form of hyperbolic signatures in some of the records, indicating the presence of subsidence zones prone to caving.



Typical GPR Record Showing Subsidence Zones Prone to Caving

UNDERWATER SEISMIC REFLECTION SURVEY FOR DELINEATION OF SUBSURFACE STRATIGRAPHY AT HALDIPUR PORT, KARNATAKA

M/s Mineral Enterprises Ltd (MEL) proposes to develop deep water all weather seaport with artificial harbour protection at Haldipur, Karnataka. Geophysical investigations were carried out using underwater seismic reflection study to delineate the subsurface stratigraphy including rock topography. The survey was carried out using X-star Chirp Sonar system with SB-0512i tow-fish and dual frequency echo-sounder along eleven traverses of lengths varying from 3.0 km to 10.3 km in the survey area. Position fixing and navigation of the survey vessel was carried out by deploying Sokkia Global Positioning System with beacon receiver. Results of the Chirp Sonar and dual frequency echo-sounder surveys revealed that the subsurface comprises of four to five acoustic reflectors. These acoustic reflectors were interpreted as sea-bed, silt, sandy or silty clay, clay with gravel, stiff / very stiff clay and rock topography. However, at some places, sediments also occurred in the form of pockets and lenses. The geological identification of different sediment reflectors was based on the limited data of boreholes drilled in the survey area. The level of sea-bed with respect to chart datum varied between 1.2 m and 20.6 m while that of rock ranged between 25.6 m and 60.2 m. The evaluated sea-bed and rock levels will help in calculating the quantity of sediments and rock to be dredged and extent of backwater.

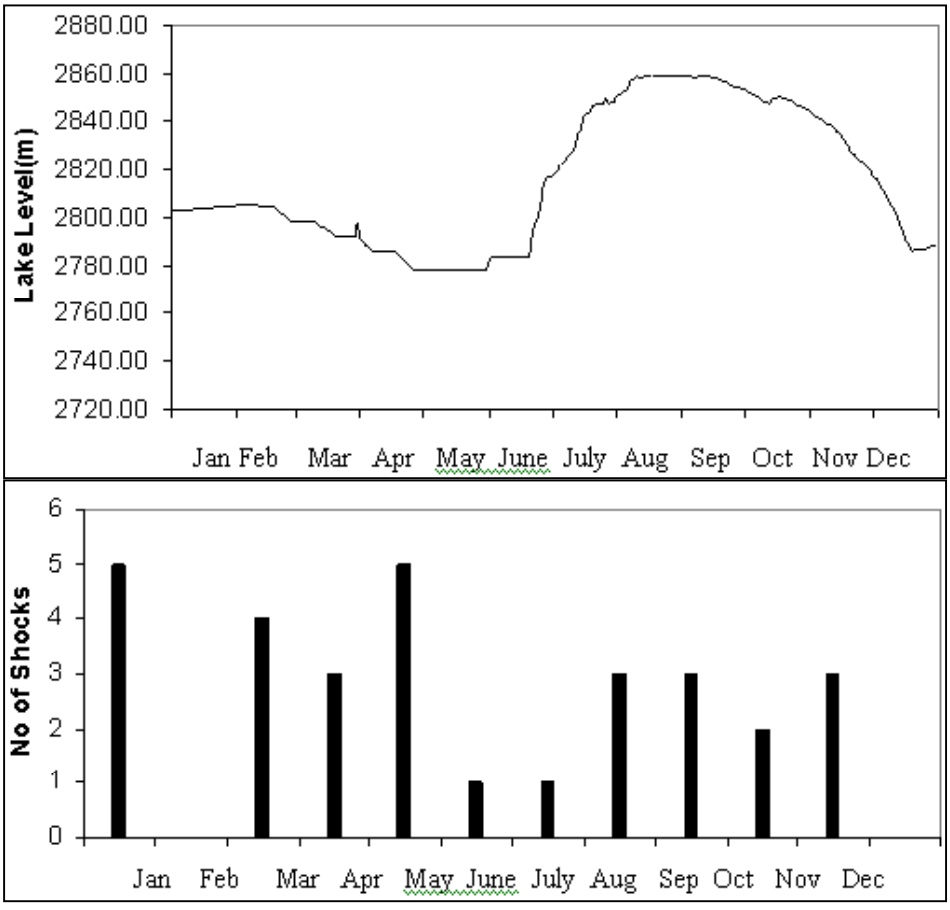


Typical Seismic Depth Section

MONITORING OF MICROEARTHQUAKE ACTIVITY AROUND HARANGI PROJECT, KARNATAKA

The Harangi project is located in southern Karnataka at 16° 12' 30" N and 75° 54' E. The area of the project falls in southern peninsular shield of India, which was considered to be seismically stable till the occurrence of Koyna earthquake of 10th December 1967. The present study was carried out to monitor the local micro-earthquake activity and to analyze the effect of reservoir impounding on the local seismicity. To accomplish this task, single station micro-earthquake recording was undertaken in 1997. The present study pertains to the period 2002 to 2005. A total of 86 events were recorded during this period, for which epicentral distances and local magnitudes were estimated by analysis of the recorded data.

The study shows that, in general, the level of observed seismicity, both in terms of magnitude and rate of occurrence has been low. Possible correlation of microearthquake activity with lake level was also studied, which did not show any definite correlation. The active Koyna-Warna region, which lies beyond 200 km, is not considered to pose any threat to the Harangi project. To locate the epicentral area, it is recommended that future recording may be done by installing a network of at least three digital micro earthquake recorders.

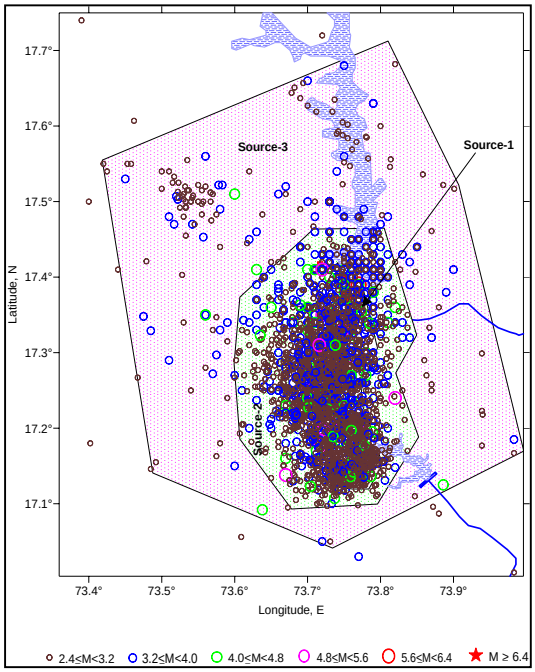


Correlation Between Number of Shocks and Lake Level Variation

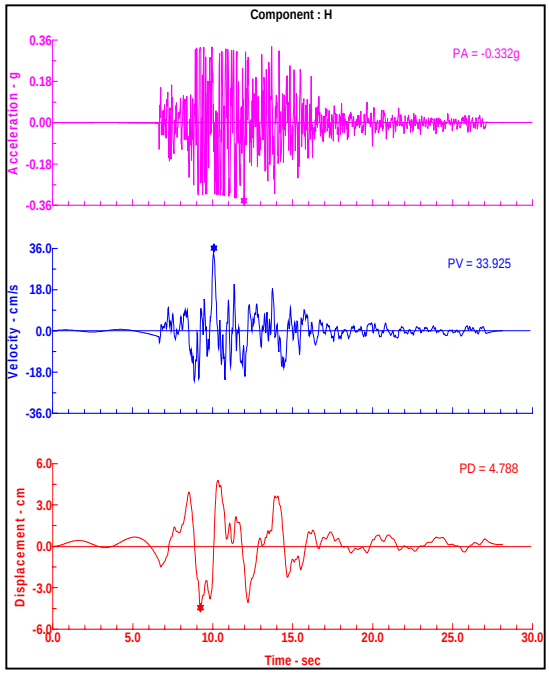
SITE-SPECIFIC GROUND MOTION FOR SEISMIC SAFETY OF HUMBARLI PUMPED STORAGE SCHEME, MAHARASHTRA

The proposed Humbarli Pumped Storage Scheme (HPSS) on Vazarde Nallah in Satara district, Maharashtra, will comprise a 450 m long and 55.55 m high masonry dam and an underground power house with installed capacity of 400 MW (2 X 200 MW). As the HPSS site is located quite close to the Koyna dam, the magnitude of the Maximum Credible Earthquake (MCE) for Humbarli project is taken as 6.8 at focal depth of 10 km. As this MCE cannot be ascribed to a specific geologic structure at a specific distance from the site, under the concept of 'floating' earthquake, the epicentral distance is taken to vary between 0 km and 30 km on the basis of the spread of epicenters. The response spectra of horizontal and vertical components for this MCE, with a confidence level of 0.84 and damping ratio of 5%, provide the MCE level of deterministic target spectra. The corresponding probabilistic target spectra based on the total expected seismicity were found to be higher than the deterministic spectra and the same have been used to generate the design ground motion to ensure adequate seismic safety.

The MCE levels of design accelerograms for horizontal and vertical components of motion have been generated to be compatible with the recommended target spectra. The values of the Peak Ground Acceleration for horizontal and vertical components were found to be 0.332 g and 0.304 g, respectively. Smoothed design response spectra for damping ratios of 1%, 3%, 5%, 7%, 10% and 15% of critical were also computed from these design accelerograms. The proposed design accelerograms and response spectra will help to evolve earthquake resistant design of the project.



Possible Seismic Sources in the Region of the Project Along With Epicenters of Past Earthquakes

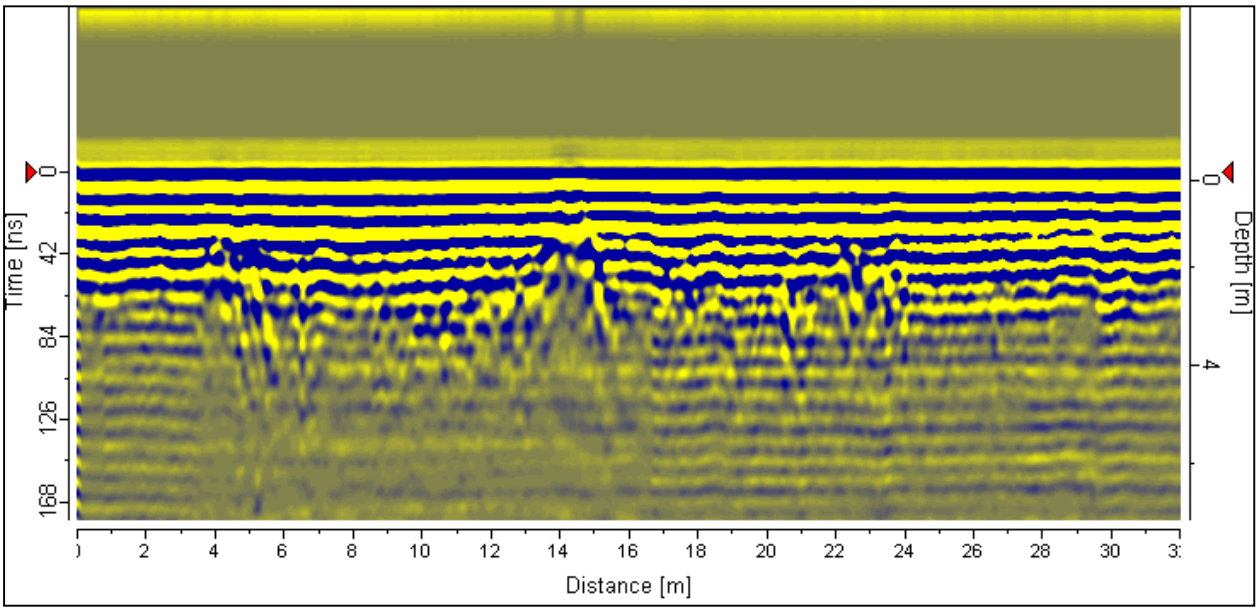


MCE level of Design Accelerogram and Computed Velocity and Displacement Records

GROUND PENETRATING RADAR SURVEY FOR IDENTIFYING CONCEALED CAVITIES IN LEFT BRANCH CANAL (LBC) OF THE TUNGABHADRA PROJECT IN KARNATAKA

Due to the problems of excessive seepage and embankment failure at high reaches in the Left Branch Canal (LBC) of Tungabhadra project in Karnataka, it was felt that cavities in the embankment portion might be responsible for these problems. CWPRS carried out studies to locate suspected cavities in reaches of 69, 77 and 85 miles of the LBC, which are considered critical.

Electrical Resistivity Imaging (ERI) method was adopted in the first phase of study during November 2007, which enabled to delineate weak zones, consisting of concealed cavities. Because of the limitations in ERI method in identification of very small size cavities, the Ground Penetrating Radar (GPR) Survey was subsequently adopted in April 2010. This method uses electromagnetic radar wave propagation through high embankment material by a transmitter and interprets the reflected wave patterns in a GPR profile known as “radargram”. A total number of seven continuous GPR profiles were taken, covering entire 3600 m stretch of interest. Standardized signature, viz. spherical/ inverted conic signature, based on experimental case studies was applied for assigning signature to a cavity in this field experiment. With this approach, more cavity locations were identified. Further, confirmation of the past observations from ERI studies was also done. The findings of this study would be useful in taking precautionary/ remedial measures in strengthening the embankment reaches affected by cavities.



A Representative Radargram Between CH: 4536.0 and CH: 4537.1

IDENTIFICATION OF CRACKS AND INTERCONNECTIVITY IN FOUNDATION AND BODY WALL OF KHADAKPURNA DAM BY NUCLEAR LOGGING AND TRACER STUDIES

The 23.55 m high and 21.30 m long Khadakpurna earthen dam, with central masonry gated spillway, is located across river Khadakpurna, a major tributary of Godavari, in Deulgaon Raja Taluka of Buldhana District, Maharashtra. It was observed during the drilling under Ogee spillway that water was oozing out from some of the holes in Monolith No. 1. It was therefore felt necessary to ascertain the extent and spreading of water by establishing interconnectivity. Apart from this, in Monolith No. 4, major cracks were observed along the body wall of the masonry and concrete blocks. It was required to ascertain the causes of occurrence of cracks and to establish the interconnectivity, if any. Nuclear logging and tracer studies were undertaken by CWPRS for this purpose.

Nuclear Logging comprising gamma-gamma density, neutron and caliper logs was conducted in eight boreholes drilled to a depth of 16 m in the foundation gallery in Monolith No. 4, and four boreholes in drainage gallery of Monolith Nos. 1 & 2. The results of nuclear logging in Monolith No. 4, indicated the presence of weak zones in the masonry portion at the top (5 m to 9 m) and at the interface between structure and foundation. The density values in these zones were less than 2.3 gm/cm^3. Tracer studies were also conducted by injecting sodium fluoroscein dye in the boreholes, drilled in Monolith No. 4 and monitoring its arrival in nearby boreholes. The results indicated that water flow was towards the gorge side through the structure-foundation interface. Similarly, it was inferred that the cracks in monolith No. 4 were throughout and interconnected. The results of nuclear logging in the drainage gallery of Monolith Nos. 1 & 2 indicated a low-density zone between 12 m to 16 m depths.. Tracer studies carried out in drainage gallery of Monolith No.2 by monitoring its arrival in the EDA had established interconnection between drainage gallery and EDA.

Based on the studies, it was recommended that the cracks observed in masonry and concrete of Monolith No.4 be treated with epoxy grouting and undertake grouting of the structure-foundation interface. Further, as the weak zones in the drainage gallery could pose leakage problem after filling of the reservoir, it was suggested that consolidated grouting may be undertaken in the drainage gallery.

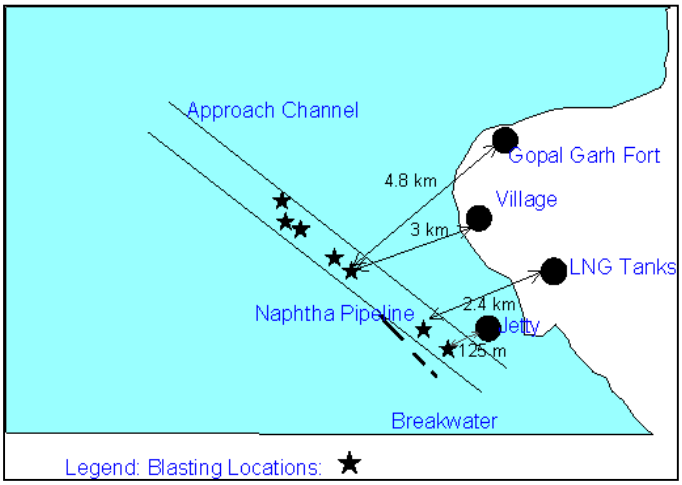
A View of Khadakpurna Dam

Cracks observed in body wall of M-4

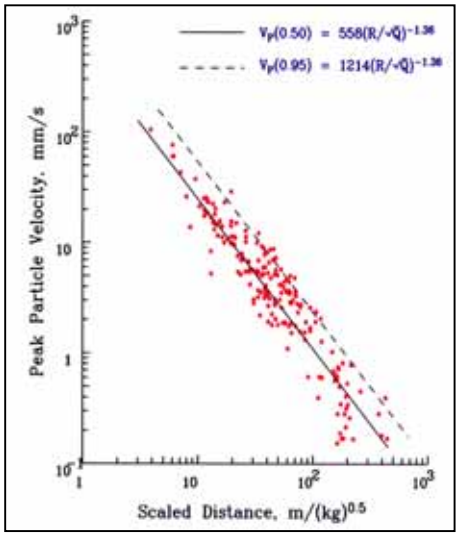
METHODOLOGY OF UNDERWATER BLASTING FOR HARD ROCK DREDGING IN APPROACH CHANNEL LEADING TO LNG TERMINAL, DABHOL

The Ratnagiri Gas and Power (P) Ltd. (RGPPL) authorities propose to remove existing hard rock (basalt) patches in the 8 km long and 300 m wide approach channel leading to LNG Terminal at Dabhol by underwater drilling and blasting. To ensure safety of surrounding structures during blasting studies were carried out to suggest the methodology of controlled blasting. For this purpose, a peak particle velocity (PPV) of 5 mm/s has been recommended as the safe vibration level. In the absence of site-specific blast vibration data, a large volume of vibration data collected from 11 construction projects having basaltic type of rock formation has been used to develop a generalized attenuation relation for PPV. Using the recommended safe vibration level of 5 mm/s in the attenuation relation with 95% confidence level, safe charge weight per delay for distance varying from 100 m to 300 m at an interval of 25 m were recommended. To facilitate removal of rock with different heights, blasting patterns for five different hole-depths, varying from 0.5 m to 1.4 m were recommended.

Monitoring the effects of blasting operations at several locations and structures, during actual blasting and taking corrective actions as needed based on feedback were also recommended. The suggested methodology for underwater blasting incorporated a number of blast procedures oriented to mitigate the adverse impacts of blasting on the marine life, the neighboring environment, onshore and offshore structures and residential communities.



Location of Rock Patches Along the Approach Channel and Nearby Structures

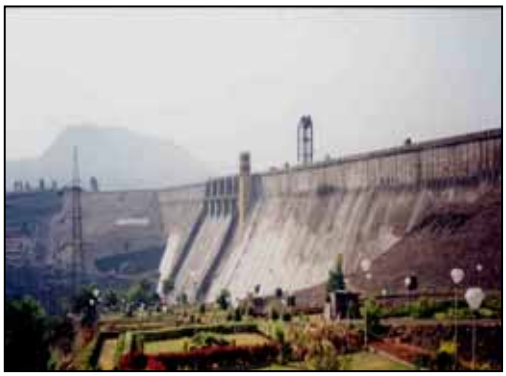


Generalized Attenuation Relations with Mean and 95% Confidence Level for Basaltic Rock

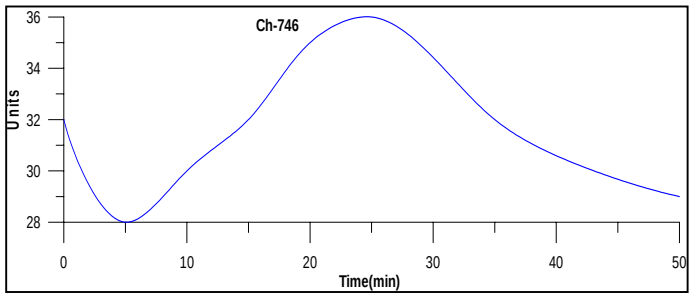
TRACER STUDIES FOR DELINEATING PATH OF SEEPAGE AT DUDHGANGA MASONRY DAM, MAHARASHTRA

The 73 m high Dudhganga masonry dam with length of 490 m and gross storage capacity of 25.4 tmc was constructed in the year 1989 in Kolhapur district of Maharashtra across river Dudhganga, a tributary of river Krishna. Excessive leakage was noticed in the drainage gallery, and it increased with the rise in reservoir level. The maximum leakage measured in the gallery as well as from the downstream face of the dam was about 350 lps. This excessive seepage through the masonry raised concern about the safety of the dam. Nuclear logging was accordingly carried out by CWPRS in the three Nx size boreholes drilled in the masonry in monoliths 5, 6 and 7 to determine the in-situ density. The results of the studies indicated that the bulk density of masonry in general varied from 2.27 g/cm^3 to 2.52 g/cm^3. Accordingly, tracer studies were conducted to delineate path of seepage through the body of the dam.

Tracer studies were conducted by injecting potassium permanganate/ sodium fluorescein dye at various depths in the upstream of reservoir and in the boreholes on the dam top. Its arrival at different sampling points was monitored in the downstream portion of the dam as well as in the drainage gallery to ascertain interconnectivity. The samples were analyzed on a fluorometer. Tracer injected in the boreholes where the zones of low density (encountered by nuclear logging) and analysis of samples at different seepage locations in the downstream side and the drainage gallery portion have shown that the seepage path is from the upstream to the downstream in the body of the dam. The tracers injected at the junction of monolith and in the reservoir at the upstream face of the dam exactly opposite the seepage points, appeared in the drainage gallery and at the downstream seepage points, indicating direct interconnection with the reservoir. The colour of the tracer was visible to the naked eye in a short span of time, inferring that the seepage water was coming with velocity. The tracer breakthrough curves indicated that path of seepage in the body of dam was tortuous and the likely cause could be weakening of cement-mortar in the body of the dam. Due to the seepage observed in the drainage gallery and downstream of the dam and also considering the tortuous path of seepage, controlled grouting from top of dam was recommended to reduce the seepage.



Downstream View of Dudhganga Dam



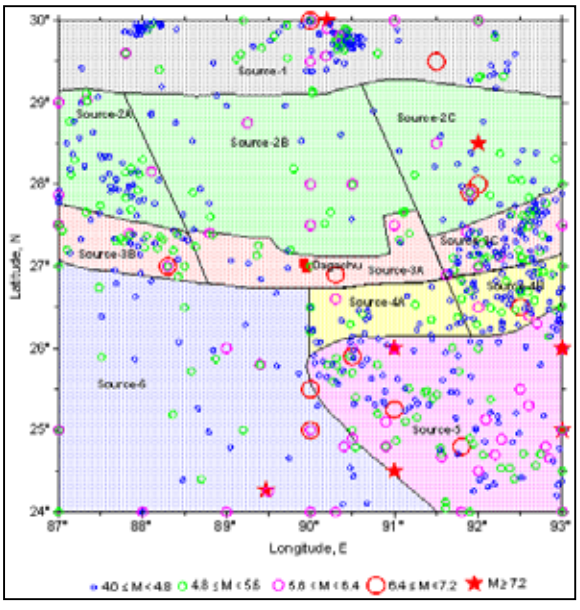
Typical Tracer Dilution Curve

ESTIMATION OF SITE SPECIFIC DESIGN EARTHQUAKE GROUND MOTION FOR DAGACHHU HYDRO POWER PROJECT, BHUTAN

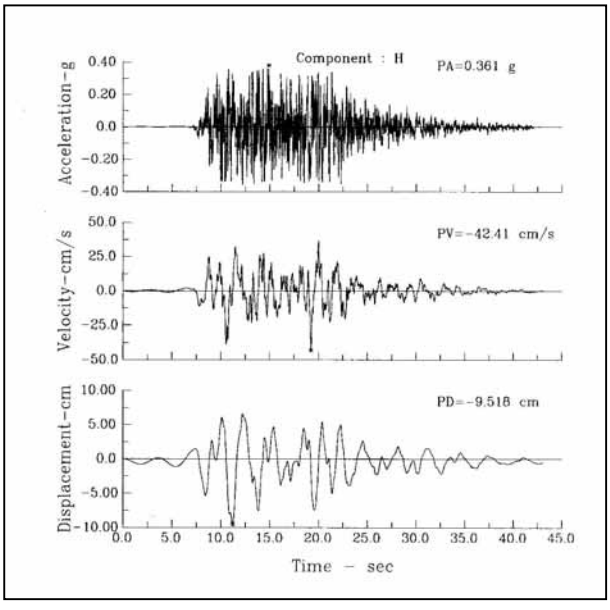
The Dagachhu Hydro Power Project (DHPP) is a run-of-the-river scheme proposed to be on river Dagachhu located in Dagana Dzongkhag district in Bhutan. A 20.5 m high concrete gravity with a crest length of 18.2 m will be used to divert the water to the power house with an installed capacity of 114 MW. The project site is located in the highly seismic Himalayan tectonic province, with very complex geological setup. CWPRS estimated Site-specific design ground motion was therefore estimated for earthquake resistant design of the Dagachhu project using available data on seismo-tectonic and geological features and past seismicity in the region. Both deterministic and probabilistic seismic hazard analysis approaches were used to arrive at very reliable estimate of the design ground motion.

The deterministic target response spectra with 5% damping were governed by the Maximum Credible Earthquake (MCE) magnitude of 8.0 at a closest distance of 22.3 km from the fault rupture plane. The corresponding probabilistic spectra were obtained by defining a composite probability distribution using the total seismicity expected to occur in the various seismic source zones identified in the region of the project to have conservative estimate of the ground motion.

The 5 % damped target response spectra obtained as above were used to generate the compatible accelerograms separately for horizontal and vertical components of ground motion. The values of the peak ground accelerations for horizontal and vertical components of motion were found to be 0.36 g and 0.22 g respectively. The acceleration response spectra for damping ratios of 1, 2, 3, 5, 7, 10 and 15 % of critical were computed from the design accelerograms to get the MCE level of design spectra. The design basis earthquake (DBE) levels of accelelograms and response spectra are to be taken as one half of the MCE level of ground motion.



Seismic Source Zones in the Region of Dagachhu Project



MCE Level of Design Accelerogram and the Computed Velocity And Displacement Records

INSTRUMENTATION, CALIBRATION AND TESTING FACILITIES

HYDRAULIC PERFORMANCE AND OVERLOAD TESTS ON SUBMERSIBLE PUMP SETS FOR UP IRRIGATION DEPARTMENT

Uttar Pradesh Irrigation Department (UPID), Lucknow, is purchasing submersible pumps in bulk quantity and installing those in bore-wells. In order to ensure trouble free operation of these pumps at site, one of the important clauses in the tender inquiry was to get one sample pump from each manufacturer tested at CWPRS as per the procedures stipulated in IS 9137. Accordingly, UPID provided the pumps of various manufacturers for evaluation of hydraulic performance as well as the performance of associated motors. These tests enables UPID to verify the specific performance guarantees quoted by the bidders in their offer against those achieved in the actual tests conducted by a neutral laboratory, so as to ensure selection of energy efficient pump sets.

Comparative hydraulic performance testing of sample submersible pump sets were undertaken for capacity 102 m^3/hr at 18 m and 48 m head and capacity 153m^3/hr at 18m and 30 m head. The hydraulic performance characteristics viz. variation of head, power input and overall efficiency against discharge, covering a minimum range of + 10% to –25% of rated head from guaranteed duty point of each pump, was determined at rated voltage of 415 Volts. Tests were also conducted to assess the performance of associated motor at over voltage (457 Volts) and under voltage (353 Volts) conditions. Performance of associated submersible motor in terms of extent of rise in temperature of its windings was also assessed when it is operated with 20 % overload of its duty power.

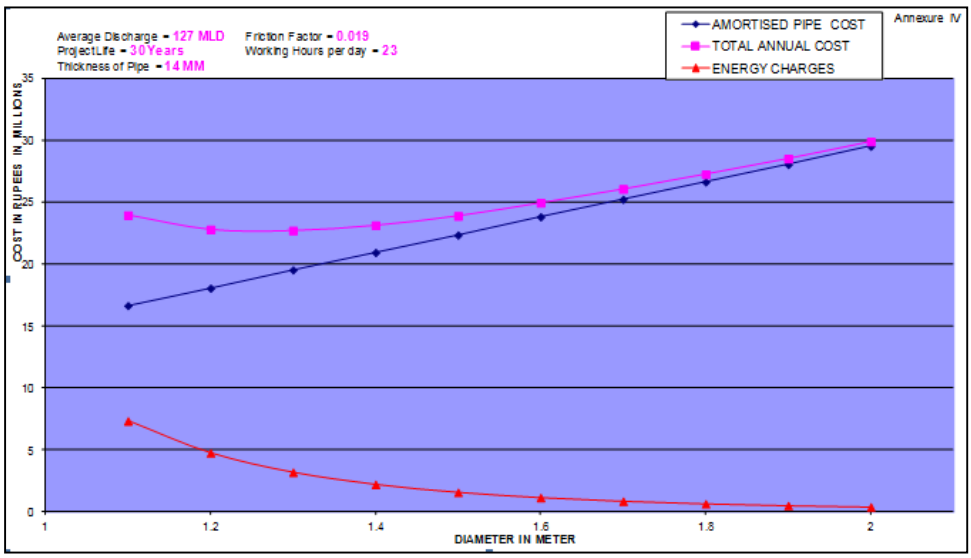
Submersible Pump Being Lowered in Pump Test Rig

HYDRAULIC DESIGN OF PUMP SUMP AND PIPELINE OPTIMIZATION FOR PUBLIC HEALTH ENGINEERING DEPARTMENT, BHOPAL

To meet the increased requirement of 340 MLD of water to Bhopal city for projected population growth, Public Health Engineering Department (PHED), Madhya Pradesh, has proposed to implement the augmentation of the capacity of drinking water Scheme for the city, which draws water from the river Narmada for two-stage pumping. CWPRS carried out desk studies for proposed raw water intake well and pump house including design of pump sump for ultimate pumping capacity and pipeline optimization.

The original proposal furnished by PHED included a jack well in river Narmada and pump house on the bank of the river Narmada, which was reviewed and modified by CWPRS to an open channel for supply of water from river to pump house. The pump sump was designed based on recommendations of Standards of Hydraulic Institute & BHRA for standard pump sump and to achieve vortex / swirl free flow conditions at pump intake. The sump was designed for a total flow rate of 340 MLD with 10 pumps each rated for 51 MLD flow rate. These minimum sump dimensions were further upgraded to take into account the actual requirements of pump manufacturer viz. dimensions of motor and the requirement of working space around the motor of each pump. The overall size of the pump house was worked out to be 24 m x 8 m to accommodate 10 vertical turbine pumps.

Further, PHED had proposed pumping out of raw water at the rate of 195 MLD to treatment plant at village Khateura. From there, the treated water at flow rate of 185 MLD was to be pumped through another pumping main to Break Pressure Tank (BPT) located 6.161 km away at Dohota Ghat. The pipe line was optimized for the average requirement of 134 MLD of raw water and 127 MLD of treated water. The pipeline diameters for these two pumping mains were accordingly optimized as 1400 mm NB and 1300 mm NB for raw and clear water pumping mains respectively. During this optimization, the pipeline life was assumed as 30 years with 23 working hours per day. The diameters of these two steel pipelines were optimized on the basis of total annual operational cost, cost of pipeline, cost of energy for pumping, depreciation and rate of interest.

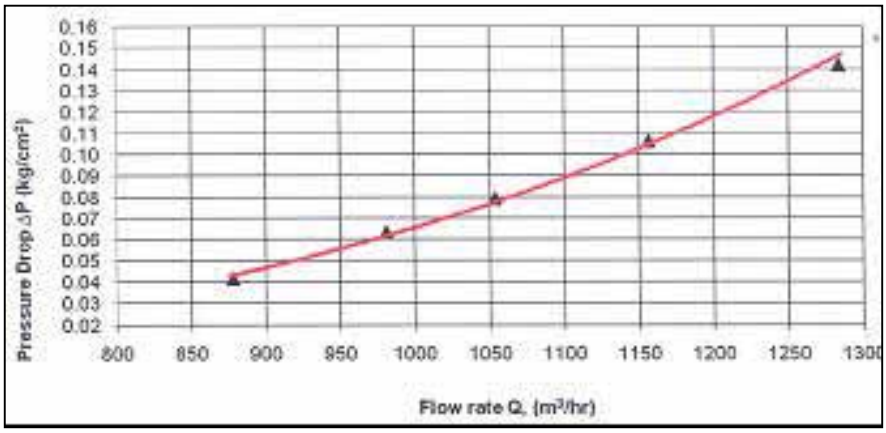


Optimization of Clearwater Pipeline for Average Discharge

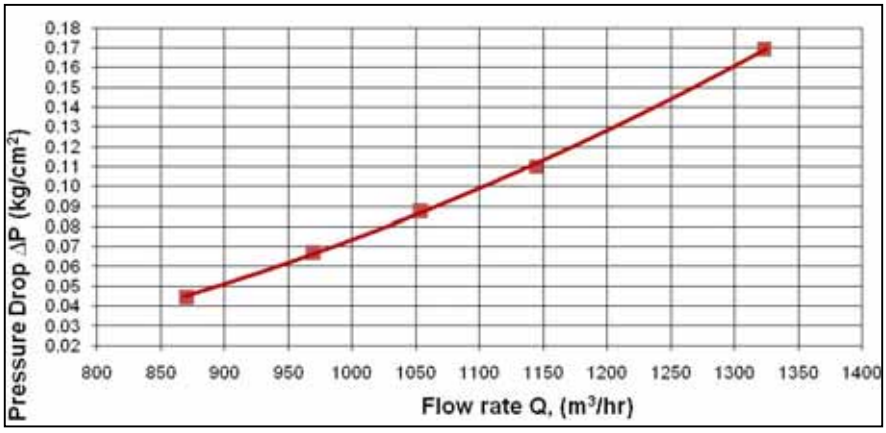
PRESSURE DROP TEST ON TEE TYPE STRAINER

Tee type strainers of 500 mm NB inlet axial nozzle and 350 mm NB radial outlet nozzle rated for flow rate of 1050 m^3/hr was supplied by M/s Gujarat Otofilt, Ahmedabad to M/s L&T for their 2 X 384 GREL CCPP Project. Since strainers are required to remove floating material in the fluid being supplied for any specific application, the strainer elements may get clogged in due course of time leading to pressure loss across the strainer. CWPRS carried out tests on the strainer to assess the head loss across the strainer at their rated flow rates with 100% clean condition of strainer element and with simulation of 50 % clogged condition.

The Tee strainer to be tested for pressure drop was kept in 500 mm NB test lines of the high precision gravimetric calibration system installed at CWPRS, by providing sufficient straight length upstream of the strainer. Pressure drop across the test strainer at different flow rates was computed from the differential pressure measured across the strainer using pre-calibrated pressure transducer. The flow rate at each test point was measured gravimetrically. Pressure drop curves thus established for the strainer for its 100 % clean condition and for 50 % blockage condition indicated that for a rated flow rate of 1050 m^3/hr the head loss values were 0.076 kg/ cm^2 and 0.086 kg/ cm^2 respectively.



Flow Rate Vs Pressure Drop for 100% Clean Condition

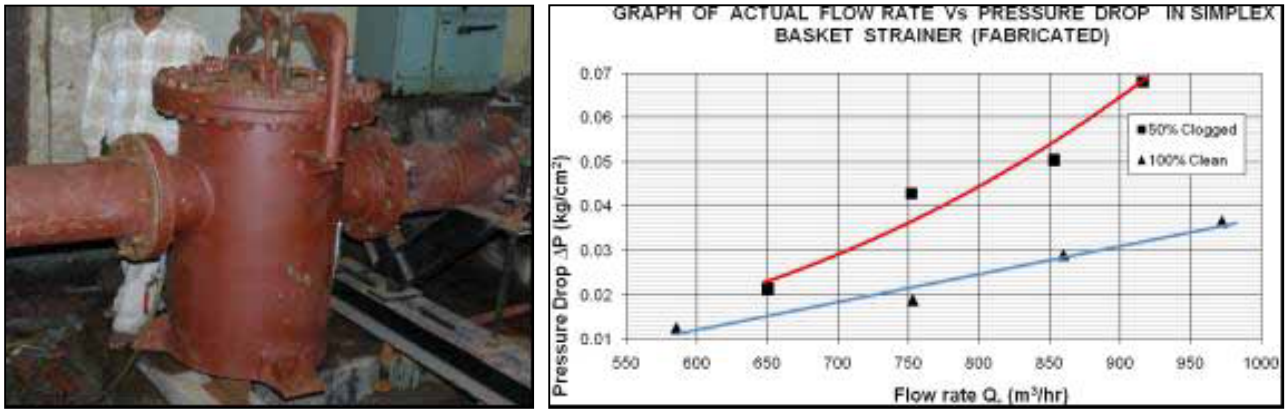


Flow Rate Vs Pressure Drop for 50% Clogged Condition

PRESSURE DROP TEST ON SIMPLEX BASKET STRAINER

Simplex basket strainers of 500NB with axial inlet nozzle and 350NB radial outlet nozzle rated for flow rate of 1050 m^3/hr was supplied by M/S. Jay-Eesh Engineering Co., Mumbai, to M/s L&T for their 2X384 GREL CCPP Project. Since strainer are required to remove floating material in the fluid being supplied for any specific application, the strainer elements may get clogged in due course of time to pressure loss across the strainer. CWPRS carried out tests on the strainer to assess the head loss across the strainer at their rated flow rates with 100% clean condition of strainer element and with simulation of 50% clogged condition.

The Simplex basket strainer to be tested for pressure drop was kept in 500 mm NB test lines of the high precision gravimetric calibration system installed at CWPRS, by providing sufficient straight length upstream of the strainer. Pressure drop across the test strainer at different flow rates was computed from the differential pressure measured across the strainer using pre-calibrated pressure transducer. The flow rate at each test point was measured gravimetrically. Pressure drop curves thus established for the strainer for its 100% clean condition and for 50% blockage condition indicated that for a rated flow rate of 1050 m^3/hr the head loss values were 0.0215 kg/ cm^2 and 0.036 kg/ cm^2 respectively.



Pressure Drop Test Setup and Pressure Drop Vs Flow Rate Curves

HYDRAULIC PERFORMANCE AND OVERLOAD TESTS OF SUBMERSIBLE PUMPSETS FOR MAHABIR EXPORTS AND IMPORT CO. LTD., GHAZIABAD

Hydraulic performance and overload tests were conducted on the following submersible pump sets:

Sr.No.	Head (m)	Flow Rate (m^3/hr)	Manufacturer
1.	18	102	M/s Mahabir Export and Import Co., Ghaziabad, U.P.
2.	42		
3.	18	153	
4.	36		
5.	36	102	M/s Kirloskar Brothers Ltd., Dewas, M.P.

The tests carried out included:

- Variation of head, power input and overall effiency against discharge covering a minimum range of + 10% to -15% of rated head from guaranteed duty point.
- Overall voltage and under voltage performance of motor of submersible pumps at 457 and 353 Volts, respectively.
- Power factor at rated output of motor.
- Temperatures rise of the submersible motor winding when the pump set was operated for an overload of 20% as well as when operated at 270 Volt for 2 Hrs. at duty point. However, with consent of M/s Mahabir Exports and Import Co., the pump sets of 42 m 153 m^3/hr ratings were tested at 340 V, because of the limitation of the circuits in term of current carrying capacity

All the above tests were carried out in accordance with the stipulation of IS 9137-1978, IS 11346-1985, IS 325-1978, IS 8034-2002 and IS 10572-1983 (reaffirmed 1993). However uncertainty levels in the measurements were much better than IS stipulations, especially for the flow rate, input power and pressure measurement. Electrical parameters were observed precisely using a Multifunction Load Manager of Conserve make, having computer compatible digital out put. Based on test results, it was recommended that in selection of the pump sets, importance be given to efficiency at duty point. It was also recommended that the randomly selected pump set from the actual batch of supply be got tested for ensuring better quality of performance of the actually supplied pump set.

Submersible Pump Installed in Test Rig

EFFICIENCY TEST OF 125 MW PUMP-TURBINE UNITS DURING GENERATION AND PUMPING MODE AT GHATGHAR HYDROELECTRIC PROJECT

A field study was undertaken to ascertain the efficiency of two turbine units of 125MW each in generation as well as pumping modes at Ghatghar Hydroelectric Pump Storage Scheme at Chondhe, Dist. Thane, Maharashtra. The upper reservoir feeding the power house with live storage capacity of 5.21 Mm^3 is situated at Ghatghar on river Pravara. The water released from the upper reservoir flows through a forebay into 700m long power pressure shaft, which bifurcates into two penstocks of 2m diameter to feed the turbines. The water released from the power house is stored in a lower reservoir with live storage capacity of 3.46 Mm^3.

To arrive at the overall efficiency of the plant during generation and pumping modes, data acquisition was made using high precision measuring instruments such as clamp-on ultrasonic flow meter for flow measurements, pressure transducers for head measurements, and power meters for power measurements. The studies were undertaken without any power interruption during the test periods and keeping the operating performance of the state grid line at optimum level. By correlating the head and discharge data with the output power generated, it is found that the overall efficiency of units 1 & 2 in generation mode is 88.56% and 87.76%, respectively. The efficiency of the units during pumping mode is found to be 85.90% and 86.68%, respectively.

The field studies undertaken by CWPRS has enabled smooth custody transfer from project authorities, viz. Department of Irrigation, Maharashtra, to the operation and maintenance authorities, viz., Maharashtra State Power Generation Company.

CALIBRATION OF CURRENT METERS

The calibration of current meters is required to establish relationship between its rotational speed and the velocity of flow. Periodical calibration is necessary to account for possible wear and tear of the parts for old current meters. As per ISO 3455, it is mandatory to recalibrate the current meters at yearly interval or after 300 hours of use, whichever is earlier. The current meter calibration facility at CWPRS comprises a 228 m long, 3.66 m wide and 2.13 m deep straight rating tank and a trolley driven by Programmable Logic Control (PLC) system. A PC based data acquisition and processing system is used for acquiring and analyzing the data.

The calibration facility conforms to International Standards (ISO 3455). The current meters to be calibrated are held by the carriage and drawn through still water contained in the tank at a number of steady speeds of the trolley in the velocity range of 0.01 m/s to 6.0 m/s. The data in respect of number of revolutions of current meter for a specified time interval is acquired and the rate of revolution of current meters (RPS) and speed of the trolley are related by one or more straight line equations.

A total of 1061 current meters were calibrated during the year, which mainly included conventional rotating element type current meters like cup type, propeller type, pigmy cup & pigmy propeller type current meters. All these current meters are used at gauging sites for discharge measurement, and were received from the organizations like Central Water Commission (CWC), State Government Departments of Water Resources Division, and Current meter manufacturers.

Current Meters Rating Trolley

Cup Type Current Meter

Propeller Type Current Meter

WATER QUALITY ANALYSIS

Facilities for in-situ and laboratory analysis of water quality in respect of physico-chemical and biological parameters are available at CWPRS. This includes water and soil analysis kit, water quality monitor (MP TROLL 9000), Secchi disc, DO sampler for in-situ studies, EC-pH-turbidity meters, Flame photometer, UV-visible spectrophotometer, BOD incubator, COD digestion apparatus and Atomic Absorption spectrophotometer. CarlZeiss compound microscope and Stereozoom microscope with camera attachments are used for analysis of biological parameters.

Water samples are tested for parameters such as electrical conductivity, pH value, temperature, secchi depth, turbidity and Dissolved Oxygen, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), nutrients and inorganic cations-anions, including heavy metals, etc. Primary productivity, planktons density and diversity in water are also tested. The test results are useful to provide the decision-support for a range of projects dealing with allocation of reservoir water for various purposes and their suitability for respective designated use.

During the current year, a total of 328 water samples were tested for various parameters for MERI, Nasik; Kosi River, Birpur; NHAI, Surat; MMRDA Mumbai; Harbour Engineering Department, Thiruvananthapuram; Water Resources Department, Sanguem-Goa, etc.

Estimation of Metal Ions in Water and Sediment Extracts Using Flame Photometer

Water Quality Data Capturing Equipment

TESTING OF SAMPLES OF VARIOUS CONSTRUCTION MATERIALS

Geotechnical Engineering and Concrete Technology Divisions at CWPRS undertake testing of samples of soil, rock, concrete and masonry for determining various engineering properties. Soil samples are generally tested for determining the properties like shear strength, consolidation characteristics and dynamic shear modulus and damping. Rock samples are tested for assessing the properties like density, Young's modulus, Poisson's ratio, tensile and compressive strengths, and cohesion and angle of friction. The concrete samples are tested for evaluation of strength, elastic, creep and thermal properties.

Equipments such as direct shear, triaxial shear, compaction, consolidation, and resonant column are available for determining the soil properties. Cylindrical soil samples are sheared in triaxial cell to determine deformation and pore water pressure. The soil properties determined in the laboratory are utilized for stress analysis, seepage studies, slope stability and dynamic analysis of earthen dams and their foundations. Rock samples are tested using equipments like triaxial cell, compression testing machine, direct shear test equipment, deformation jackets, point load testing machine, etc. Standard NX size (54 mm diameter) samples are tested by measuring stress and strains during loading/unloading. The rock properties are used for stability analysis of underground openings and design of foundations of structures. Concrete samples are tested using universal testing machine for determining strength and elastic properties, 300 Tonne Triaxial testing machine for shear strength, and 200 Tonne compressive testing machine for determining compressive strength. The concrete properties are used in assessing quality of concrete and masonry structures and strengthening/rehabilitation of major hydraulic structures.

A total of 60 soil and 15 rock samples were tested during the year for various project sites of NTPC, NPCIL, Tehri Hydro Development Corporation, State Governments of Maharashtra, Goa, Chhattisgarh and Karnataka, etc.

Triaxial Soil Shear Test Equipment

Point Load Test Equipment

CALIBRATION OF FLOWMETERS AND TESTING OF FILTERS AND VALVES

Calibration of flow meters is essential for measurement of water transfer from supplying agencies to end users, interstate sharing of water, flow through hydro turbines in hydropower sector, etc. Filters are used to remove the suspended particles in water to supply clean water for steam generation in thermal power plants, and are required to be tested for the pressure drop, which defines their efficiency. Valves are usually used to control the flow rate in any flow process system, and they are required to be tested to ascertain their characteristics, viz., valve opening versus discharge and the valve opening versus head loss. Gravimetric and volumetric calibration facilities conforming to ISO 4185 are available at CWPRS for calibration of flow meters, testing of filters and ascertaining flow valve characteristics as detailed below:

Gravimetric Calibration facility	**Volumetric Calibration facility**
Maximum line size : 1000 mm NB. (May be extended up to 1200 mm NB)	Maximum line size : 250 mm NB
Maximum flow rate : 7200 m^3/hr	Maximum flow rate : 300 m^3/hr
Calibration uncertainty : +/- 0.3 %	Calibration uncertainty : +/- 0.5 %
Capacity of tank : 100 tonnes	Capacity of tank : 3861.625 Ltr

The principle employed in the gravimetric calibration facility is to accurately weight the quantum of water passing through the flow meter under calibration at constant flow rate in a precisely known interval of time. The ratio of weight to time is the primary measure of flow rate against which the flow meter is calibrated. On the other hand, volume is measured in the volumetric calibration facility.

As regards testing of valves, 14 studies were conducted for clients like Weir BDK Valves, Hubli; Spirex Marshall, Pune; Kirloskar Bros. Ltd. (Valves Divn.), Pune; Jay-eesh Engg.Co., Mumbai; Gujrat Otofilt, Ahmadabad; Filtration Engineers India Pvt. Ltd., Mumbai; Varall Engineers , Mumbai; Otoklin Global Business, Mumbai; Flashpoint , Pune ; Uni Klinger Ltd. , Pune; Pennant Engg. Pvt. Ltd., Pune; Driplex Water Engg. Ltd., Pune; BHEL, NTPC, NHPC, etc. The various types of valves tested include Sluice Valve, Butterfly Valve, Globe Valve, Ball Valve etc. Testing of filters was carried out for Nivo Controls Ltd., Indore ; Micamachi Inc., Pune; Aquameas Inst. Pvt. Ltd., Pune; Manas Microsystems, Pune ; SBEM Pvt Ltd., Pune ; Maharashtra Jiwan Pradhikaran, Municipal Corporations; Electronet Equipments Pvt. Ltd., Pune; Axelia-Chetas JV, Pune ; Siemens India Ltd, Mumbai ; Endress & Hauser , Mumbai; Honeywell Automation India Ltd., Pune; Mitcon Consultancy Services Ltd., Pune; Kay Cee Industries Ltd., Mumbai; Samtech Engg. Services, Secunderabad; Actaris Industries (I) Pvt. Ltd., Mumbai; Hi-Tech Systems and Services, Kolkata; in which pressure drop across the filter was measured at 100% clean condition and for 50% clogged condition. If the pressure drop is found to exceed the permissible value prescribed by the manufacturer, the filter has to be cleaned / changed.

Gravimetric Calibration Facility

Volumetric Calibration Facility

DISSEMINATION OF INFORMATION

AN OVERVIEW

Dissemination of information and research findings forms an important part of the mandate of CWPRS. Research papers are published in National and International Journals and are presented in Seminars, Symposia, Conferences, etc. by carrying out basic and fundamental research necessary to upgrade and improve upon the sponsored applied research. During the year, a total of 96 research papers were published on a wide variety of topics within the areas of expertise of CWPRS. Also, 50 scientists participated in 23 different Seminar/Symposia/Conferences/Workshops and interacted with the hydraulic research fraternity in the country.

Technical Memorandum/Guidelines/State of the Art Reports are compiled based on the large research experience of CWPRS in different areas. During the year technical memorandum on "Guidelines for Design and Construction of Seawalls" was published. Such publications are useful for research/Design/Practicing engineers.

A number of specialized training programs are organized with CWPRS scientists as faculty to impart training to the field engineers, researchers, academicians, etc. In addition, experts from CWPRS also deliver lectures on topics of their expertise at other organizations. During the year, CWPRS organized 11 courses and 53 invited lectures were delivered by its experts at other organizations.

CWPRS has nominated experts for 10 out of 12 of the Sectional Committees under Water Resources Division Council (WRDC) of BIS, New Delhi. Director CWPRS is the Chairman of Sectional Committee WRD 1 on "Hydrometry". Experts are also nominated for Civil Engineering Division (CED) Sectional Committees: CED 38 (Earthquake Engineering), CED 48 (Rock Mechanics), and CED 47 (Ports, Harbour and Offshore Installation). Significant contributions are also made in the ISO TC113 Committee on "Hydrometry" with Director CWPRS as the Chairman of its Sub-committee SC6 on "Sediment Transport". During the year, a number of new Standards were drafted and several existing Standards were revised and confirmed.

Scientists from CWPRS are the members in several committees of experts constituted by different state and central government organizations and ministries. Based on the experience and expertise of CWPRS important advice and recommendations are provided by participation in the meetings of such expert committees. During the year, 45 experts of CWPRS participated in 25 different meetings.

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71. Roman, U.C., S. Narasaiah, K. Narsayya, 'Establishing original elevation capacity curve of a reservoir using past satellite data', Procs. of Natl. Conf. on Hydraulics, Water Resources, Coastal and Environmental Engineering, HYDRO 2010, MMEC, Mullana, Ambala, Haryana, pp.377-383, December 2010.

72. Roman, U.C., Suneeta Jatwa, M.N. Singh, S. Selvan, 'Reservoir capacity loss examination using satellite data' GEOtrendz – Indian Geotechnical Conf., IGC-2010, IIT Mumbai, Vol. II, pp. 1083-1086, 16-18 December 2010.

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75. Singh, A.K., V.B. Sharma, L.R. Ranganath, C.B. Singh, 'Numerical investigation of tide induced circulations in a typical estuary due to construction of breakwaters'; Procs. Natl. Conf. on Civil Engineering for Infrastructural Developments, CID 2010, D.Y. Patil College of Engineering, Akurdi, Pune, pp. 297-301, 30-31 August 2010.

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79. Singh, Raghuram B., Anuja Rajgopalan, M.N. Singh, M.K. Pawar, 'Application of remote sensing in river morphology' Procs. of Natl. Conf. on Hydraulics, Water Resources, Coastal and Environmental Engineering, HYDRO 2010, MMEC, Mullana, Ambala, Haryana, pp. 683-691,16-18 December 2010

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81. Singh, Raghuram B., M.N. Singh, "Studies for improvement of flow conditions at proposed barrage across river Falgu", ISH Journal of Hydraulic Engineering, Vol. 17(1), pp. 50-57, March 2011.

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87. Tripathy, G.R., R.R. Shirke, 'Assessment of safety of earthen dams against ground vibrations due to mining blasts', Procs. of 'Mine TECH 10', Seminar on Mining Technology-Extraction, Beneficiation for Safe and Sustainable Development, Organized by the Indian Mining and Engineering Jour. at Bhubaneswar, pp. 202-210, 7-8 May 2010.

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89. Verma, M.K., A.P. Meshram, M.K. Pawar, 'Optimizing the size of open channel desilting basins', Procs. of Natl. Conf. on Hydraulics, Water Resources, Coastal and Environmental Engineering, HYDRO 2010, MMEC, Mullana, Ambala, Haryana, pp. 22-28, 16-18 December 2010.

90. Vijayagopal, P., S. Govindan. , F.T Mathew, `Use of operational hydrology techniques for water resources assessment'; Procs. of the Natl. Conf. on water for future, Shri Govind Singh Institute of Engineering and Technology, Nanded, 25-26 February 2011.

91. Vivekanandan, N., F.T. Mathew, 'Assessing adequacy of a probability distributional model for flood estimation'; Procs. of Natl. Conf. on Geo-sciences and Water Resources for Sustainable Development at Andhra University, Visakhapatnam, 11-12 February 2011.

92. Vivekanandan, N., Janga Reddy M., 'Optimal irrigation planning using linear and goal programming approaches'; Procs. of Natl. Conf. on Hydraulics, Water Resources, Coastal and Environmental Engineering, HYDRO 2010, MMEC, Mullana, Ambala, Haryana, pp. 881-888, 16-18 December 2010.

93. Vivekanandan, N., 'Prediction of Runoff using artificial neural networks', Procs. of Ninth Intl. Conf. on Hydro-Science and Engineering, ICHE 2010, IIT, Madras, Chennai, pp.1691-1699, August 2010.

94. Vivekanandan, N., F.T. Mathew, 'A comparative study of flood estimation using data transformation methods' Procs. of Ninth Intl. Conf. on Hydro-Science and Engineering, ICHE 2010, IIT, Madras, Chennai, pp. 581-588, August 2010.

95. Vivekanandan, N., F.T. Mathew, 'Comparison of T-year flood estimates by a range of statistical distributions' Indian Jour. of Power & River Valley Development, Vol. 60, pp. 90-94, May-June 2010.

96. Vivekanandan, N., F.T. Mathew, 'Probabilistic modelling of annual d-day maximum rainfall' ISH Jour. of Hydraulic Engineering, Vol. 16, No.1, pp. 122-133, November 2010.

PARTICIPAPTION IN SEMINARS/ SYMPOSIA/ CONFERENCES/ WORKSHOPS

No.	Event	Organiser, Date and Place	Name of officer(s)
1.	Seminar on "Mining Technology-Extraction, Beneficiation for Safe & Sustainable Development –Mine TECH-10"	Indian Mining & Engineering Journal, 07-08 May 2010, Bhubaneshwar	G. R. Tripathi (Dr.), RO
2.	Workshop on "Harvest Rainwater and Recycle Water for Future"	Vision India, 16 July 2010, Pune	K. Venugopal (Dr.), CRO
3.	Ninth International Conference on "Hydro-Science and Engineering (ICHE 2010)"	Department of Ocean Engineering, IIT Madras, 02-05 August 2010, Chennai	C.B. Singh (Dr.), JD L.R. Ranganath, SRO Kuldeep Malik, RO N. Vivekanand, ARO Naveed Ali, ARO S.N. Jha, RA
4.	International workshop on "Geo-Synthetics and Modern Materials in Coastal Protection and Related Applications"	IIT, Madras, 06-07 August 2010, Chennai	M.D. Kudale, JD
5.	Indo – US Bilateral Workshop on "Sedimentation, Erosion, Flooding and Ecological Health of Rivers"	ISI, 01 – 03 November 2010, Kolkata	M. N. Singh, CRO S. N. Das, ARO
6.	XIX Congress of APSMS 2010 and National Conference of "Mathematical Aspects of Cryptography and Network Security"	Jyothishmathi Institute of Technology & Science, 12-14 November 2010, Karimnagar, Andhra Pradesh	A.K. Bagwan (Dr.), ARO
7.	All India Seminar on "Geo Synthetics – Innovative & Environmentally Sustainable solution for Civil Engineering Projects"	Institute of Engineers (India), 27 – 28 November 2010, Ahmedabad	A.V. Sitaram Sarma, RO
8.	Second International Conference on "Coastal Zone Engineering and Management (Arabian Coast – 2010)"	Sultan Qaboos University, Muscat, 31.10.2010 to 03.11.2010, Sultanate of Oman	Hradaya Prakash, SRO
9.	Short course on "Hydraulics, River Engineering and Application of Hydraulic Modelling Techniques"	CWPRS, 08-10 December 2010, Pune	V. S Jain, RA S. Patnaik (Mrs.), RO P. Vijayagopal, RO Syed Naveed Ali, ARO

10.	Indian Geo-technical Conference-2010	IIT Bombay, 16-18 December 2010, Mumbai	Sunita Jatwa, ARO M.S.Hanumanthappa, RO
11.	Fourth International Conference on "Fluid Mechanics and Fluid Power"	IIT Madras, 16-18 December 2010, Chennai	K. Kumar, RO
12.	National Conference on Hydraulics, Water Resources, Coastal & Environmental Engineering – HYDRO – 2010	MM Engineering College, Mullana, 16-18 December 2010, Ambala	M.D Kudale, JD P.K. Goel, CRO T. Nagendra, CRO S.G Hardikar (Mrs.), SRO H.B., Jagadeesh, SRO U. C. Roman, SRO Prabhat Chandra, CRO
13.	14th Symposium on "Earthquake Engineering"	IIT Roorkee,17-19 December 2010, Roorkee	I. D. Gupta (Dr.), Director
14.	International Conference on "Geophysical Sciences – Energy, Climate Change and Evolution of Human Society"	BHU, 21-23 December 2010, Varanasi	S.D. Marulkar, RO
15.	Convention & Exhibition on "Scientific & Technological Approaches for Sustainable Use of Water Resources"	GIST Convention 2010, 26-27 December 2010, IMCC, Pune	K. Venugopal (Dr.), CRO
16.	National Symposium on Instrumentation	VTU, Belgaum, 07-09 January 2011, Belgaum	Lata Gupta (Mrs.), RO N.P Khaparde, CRO S.V Phadke, (Mrs.), CRO
17.	National Conference on "Geosciences & Water Resources for Sustainable Development"	Andhra University, 11-12 February 2011, Visakhapatnam	N. Vivekanandan, ARO
18.	International Conference on "Sustainable Water Resources Management and Climate Change Adaptation (SWRMCCA)"	NIIT Durgapur,17-19 February 2011, Durgapur	S. P. Vaidya (Dr.) (Mrs.), SRO
19.	National seminar on "Explosives and Blasting Techniques for Mining Quarrying & Infrastructure Industry (EBTMQI)"	Dept. of Mining Engg., NITK, Surathkal, 18-19 February 2011, Surathkal	G.R. Tripathi (Dr.), SRO
20.	Seminar on "Hydraulic Instrumentation"	BIS, 24 February 2011, New Delhi	M.N Singh, CRO Rizwan Ali, SRO P.D Kamalasekaran, SRO
21.	Seminar on "Canal Automation Studies in CWPRS"	CBIP, 24-25 February 2011, New Delhi	Mukesh Arora, SRO

22.	National Conference on "Water for Future (NCWF – 2011)"	SGGS College of Engg. 25-26 February 2011, Nanded	R.G. Patil (Dr.), SRO P. Vijayagopal, RO
23.	Workshop on "Applications & Uses of Vibration & Acoustics in Industries"	Envicon Bangalore 25 February 2011, Pune	N.B Varshikar, RO V.K. Ghodake, ARO

PARTICIPATION IN TRAINING PROGRAMS

No.	Event	Organizer, Date and Place	Name of officer(s)
1.	Workshop on "Client Connection"	World Bank, 20 April 2010, New Delhi	U.C. Roman, SRO G.U. Mangoli, AAO
2.	Training Programme on "Application of GIS in Water Resources"	NWA, 07-18 June 2010, Pune	G.V. Ramana Rao, SRO M. Selva Balan, SRO P.S., Kunjeer, RO F.D. Momin, ARO Anuja Rajagopalan (Mrs), ARO P.D. Patil, RA
3.	"Ground Water Issues and Database Management" under HP-II	NIH, 10 –11 June 2010, Roorkee	C. Ramesh (Dr.), RO
4.	"Latest Advances in Flood Forecasting and Early Warning Systems" under HP-II	CWC, 25 June 2010, New Delhi	I. D. Gupta (Dr), Director C. Ramesh (Dr.), RO
5.	Training Programme on "Radiation Safety Aspects of Nucleonic Gauges"	BARC, 14-22 June 2010, Mumbai	Amol Chunade, RA
6.	Training Programme on "Environmental Aspects of Water Resources Projects"	NWA, 02-16 July 2010, Pune	S. S. Kerimani, RO A.K. Bagwan (Dr.), ARO S. N. Jha, RA
7.	Training Workshop on "Predictions in Ungauged Basins"	NIH, 26-30 July 2010, Roorkee	P. Vijaygopal, RO
8.	Training Programme on "The World Bank Procurement Procedures"	NWA, 06-30 July 2010, Pune	U.C. Roman, SRO S.H. Kulkarni (Miss), ARO
9.	Training Programme on "Reservation in Services for Schedule Casts, Schedule Tribes and OBC"	Institute of Secretariat Training & Management, 09-12 August 2010, New Delhi	M.K. Pawar, CRO
10.	Training Programme on "Communication and Presentation Skills for Scientists"	DST, 23-28 August 2010, Bhubaneshwar	V. J. Shende (Mrs), CRO A. M. Vaidya (Mrs), CRO
11.	Training on "HYPACK Hydrographic Survey Software"	M/s ASB Systems, Mumbai, 23-25 August 2010, Goa	M. Selvabalan, SRO
12.	Training on "Coastal Engineering and Coastal Zone Management"	NWA, 23-27 August 2010, Pune	S. Narasaiah, RO R.K. Choudhary, ARO
13.	Workshop on "Dam Safety Evaluation and Risk Assessment"	CSMRS, 31.08.2010 to 01.09.2010, New Delhi	Rizwan Ali, SRO V.T. Desai, SRO

14.	Course on "Characterization of Rock Fill Materials"	CSMRS, 09-10 September 2010, New Delhi	J.S. Edlabadkar (Mrs.), RO
15.	Refresher course for in service ISS officers "General Management"	National Academy of Statistical Administration,13-24 September 2010, IIM, Lucknow	R. S. Jagtap, SRO
16.	Training Programmme on "Application of Information Technology in Water Resources Sector"	NWA, 04-08 October 2010, Pune	P. H. Tarudkar, ARO P. S. Solanki, ARO
17.	Workshop on "Communication Skills"	ISTM, 25-27 October 2010, New Delhi	L.R. Ranganath, SRO
18.	Training Programme on "Global Warming and Climate Change"	DST and IITM, 01-21 December 2010, Pune	S. Kannan, ARO
19.	Training Programme on "Multi-hazard (Tsunami, Storm Surge and Sea Level Rise) and Vulnerability Mapping"	ICMAM, 06-10 December 2010, Chennai	A. V. Sita Rama Sarma, RO
20.	Training Programme on "Application of Finite Element Analysis for Water Resources Structures"	NWA, 06-16 December 2010, Pune	V. S. Ramarao, RO
21.	Training of MIKE 3 Software	NPCIL, 13-17 December 2010, Mumbai	B.M. Patil (Dr), CRO L.R. Ranganath, SRO Jiweshwar Sinha, SRO K. H. Barve, ARO R. Manivanan (Dr.), ARO S.N. Jha, RA
22.	International workshop on "River Management (IWRM-2010)"	NIH Roorkee, 14-16 December 2010, New Delhi	M.N Singh, CRO Arun Kumar, RO
23.	Workshop on "Generic DSS(P) Development"	NIH, Roorkee, 07 January 2011, CWC, New Delhi	C. Ramesh (Dr.), RO M. M. Kshirsagar (Dr.), SRO
24.	Workshop on "Introduction to Information Security"	CERT-In, Department of Information Technology, 28 January 2011, New Delhi	P.R. Khatarkar, SRO
25.	Workshop on "Results Framework Documents for Responsibility Centers (RCs)"	Performance Management Division, under PMO, 22 February 2011, New Delhi	F. T. Mathew, JD M. K. Pawar, CRO
26.	Workshop on "Training Coordinators"	NWA, 28 February 2011, Pune	F. T. Mathew, JD
27.	Training Programme on "Water Quality Management (Surface Water)"	NWA, 07-16 March 2011, Pune	V. M. Prabhakar (Dr), ARO

28.	Workshop on "Web Application Security: Current Trends"	CERT-In, Dept. of Information Technology, 18 March 2011, New Delhi	P.R. Khatarkar, SRO P. S. Solanki, ARO
29.	Refresher Training for in-service officer of ISS on "Project Management"	Central Statistical Organization, 14-18 March 2011, ASCI, Hyderabad	Kajal Jain (Mrs.), RO

Participation in Training Programme on Multi-Hazards (Tsunami, Storm Surge and Sea Level Rise) and Vulnerability Mapping, Organized at ICMAM, Chennai 6th –10th December 2010

Participation in International Workshop on River Management (IWRM-2010), Organized by NIH, Roorkee at New Delhi 14th -16th December 2010

COURSES ORGANIZED

1. Training Program on “Coastal Engineering & Coastal Zone Management” organized by CWPRS in collaboration with National Water Academy, Pune during 23–27 August 2010 at NWA, Pune
2. Training Programme on `Calibration of current meters and their usage in rivers’ conducted at Panjim, Goa jointly by CWPRS and Goa during 28-30 September 2010
3. A 3-day Training Programme on `Application of Statistical Methods in Hydrology’ during 19-21 October 2010 at CWPRS
4. Five-day Training Course organized by CWPRS for participants of long hydrographic course (NIH), Goa during 22-27 November 2010
5. Training Programme on “Methodologies for Assessment of Reservoir Sedimentation" organized by CWPRS during 1-3 December 2010
6. Short course on "Hydraulics River Engineering and Application of Hydraulic Modelling Techniques", organized by CWPRS during 8–10 December 2010
7. A Training Course on “Coastal Erosion and Protection” was organized by CWPRS, at Mumbai for engineers of coastal wing, PWD, Maharashtra during 5-6 January 2011
8. Training Course on “Modern Methods in Canal Control & Operations” organized by CWPRS during 18-20 January 2011
9. Training Course on “Coastal Erosion and Protection”, organized at CWPRS during 8-11 February 2011
10. National Workshop on “Environment, Dams and Ports” organized by CWPRS, BVPDU and ISH at BVPDU during 15-16 February 2011
11. Workshop on `Optimization of gauge discharge stations and rain gauge network in Maharashtra’ was conducted on 28th February 2011 jointly by CWPRS and Government of Maharashtra (GoM) at Jal Vigyan Bhawan, Nasik

Training Course on Hydraulics, River Engineering and Application of Hydraulic Modelling Techniques held at CWPRS on 8th –10th December 2010

Training Course on Modern Methods in Canal Control and Operations held at CWPRS on 18th –20th January 2011

Dr. I.D. Gupta, Director, CWPRS Presenting Certificates to the Participants of a Short Course on Methodologies for Assessment of Reservoir Sedimentation organized by CWPRS on 1st –3rd December 2010

LECTURES DELIVERED AT VARIOUS ORGANIZATIONS

No.	Title	Event	Date	Name of Officer
1.	PID, FUZZY, feed back controllers for process automation	Guest lecture for students of Final Year (B.E.) Instrumentation Engg., VIT College, Pune	4 April 2010	M. Selva Balan, SRO
2.	Water quality studies for Bhima basin : A Case study	Training Programme on "Water Quality Management for Lakes and Reservoirs" at NWA, Pune	19 April 2010	S.P. Vaidya S.P (Dr.) (Mrs.), CRO
3.	Experience with the use of Geo-synthetic Materials in Coastal Protection Works	International workshop on Geo-Synthetics and Modern Materials in Coastal Protection and Related Application, IIT Madras	6 August 2010	M.D. Kudale, JD
4.	Overview of Coastal protection in India and Innovative Methods of Protection	Training on Coastal Engineering & Coastal Zone Management, NWA, Pune	23 August 2010	M.D. Kudale, JD
5.	Wave Structure Interaction	Training on Coastal Engineering & Coastal Zone Management, NWA, Pune	24 August 2010	J.D. Agrawal, SRO
6.	Coastal Processes	Training on Coastal Engineering & Coastal Zone Management, NWA, Pune	24 August 2010	J.D. Agrawal, SRO
7	Tidal Hydraulics	Training on Coastal Engineering & Coastal Zone Management, NWA, Pune	24 August 2010	A.V. Mahalingaiah, SRO
8.	Coastal Sedimentation	Training on Coastal Engineering & Coastal Zone Management, NWA, Pune	24 August 2010	Ranganatha L.R., SRO
9.	Field data requirements, collection and analysis	Training on Coastal Engineering & Coastal Zone Management, NWA, Pune	24 August 2010	Purohit A.A., SRO

10	Hydraulic Modelling Techniques in Coastal Engineering	Training on Coastal Engineering & Coastal Zone Management, NWA, Pune	24 August 2010	T. Nagendra, CRO
11.	Littoral Drift and Shoreline Evolution	Training on Coastal Engineering & Coastal Zone Management, NWA, Pune	25 August 2010	B.M. Patil (Dr.), CRO
12.	Simulation for Locating Marine Outfalls	Training on Coastal Engineering & Coastal Zone Management, NWA, Pune	25 August 2010	R. Manivanan (Dr.), ARO
13.	Design Wave Prediction and Storm Surge Analysis	Training on Coastal Engineering & Coastal Zone Management, NWA, Pune	25 August 2010	M.D. Kudale, JD
14.	Design & Construction of Coastal Structure	Training on Coastal Engineering & Coastal Zone Management, NWA, Pune	25 August 2010	A.V. Sita Rama Sarma, RO
15.	Coastal Inlets and Development of Fishing Harbours	Training on Coastal Engineering & Coastal Zone Management, NWA, Pune	27 August 2010	N. Ramesh, SRO
16.	An Overview of changing scenario in modeling techniques in Coastal Engineering problems	Training on Coastal Engineering & Coastal Zone Management, NWA, Pune	27 August 2010	C.B. Singh (Dr.), JD
17	Roles and functions of CWPRS	NWA, Pune	3 September 2010	I.D. Gupta (Dr.), Director, CWPRS
18.	Fundamentals of Structural Dynamics	NWA, Pune	13 September 2010	I.D. Gupta (Dr.), Director, CWPRS
19.	Importance of model studies in Design of Water Resources Structures	Training Programme for new appointees of Central Water Engineering (Group A) Services NWA, Pune	13 September 2010	V.V. Bhosekar (Smt.), CRO
20	Hydraulic Design of Dam and appurtenant structures – a case study	Training Programme for new appointees of Central Water Engineering (Group A) Services, NWA, Pune	13 September 2010	V.V. Bhosekar (Smt.), CRO

21.	Dynamic Analysis of Concrete Dams	Training Programme for new appointees of Central Water Engineering (Group A) Services, NWA, Pune	16 September 2010	L.R. Pattanur (Dr.) (Ms.), RO
22.	Analysis of underground cavities using FEM	Training Programme for new appointees of Central Water Engineering (Group A) Services, NWA Pune	17 September 2010	K.R. Dhawan (Dr.), CRO
23.	Dynamic analysis of concrete gravity dams	NWA, Pune	17 September 2010	I. D. Gupta (Dr.), Director, CWPRS
24.	Design and simulation of tide generations	Course on "Advances in Fluid Mechanics" organized by Sou. Venutai Chavan Polytechnic, Pune at Sou. Venutai Chavan Polytechnic, Pune	4-8 October 2010	M.S. Bisht, RO
25.	Application of 1st law of Thermodynamics and Testing of pumps	Course on "Advances in Fluid Mechanics" organized by Sou. Venutai Chavan Polytechnic, Pune at Sou. Venutai Chavan Polytechnic, Pune	4-8 October 2010	Abdul Rahiman P.M., SRO
26.	Problems in Field Applications of pumps and Turbines	Course on "Advances in Fluid Mechanics" organized by Sou. Venutai Chavan Polytechnic, Pune at Sou. Venutai Chavan Polytechnic, Pune	4-8 October 2010	Raman Murthy G.V., RA
27	Global Positioning System and its Application	Training Program on "Application of RS GIS in Water Resources" organized by NWA, Pune	23 November 2010	M. Selva Balan, SRO
28.	VB-6 Interfacing with ARC-GIS	Training Program on "Application of RS GIS in Water Resources" organized by NWA, Pune	26 November 2010	P.S. Solanki, ARO

29.	Analysis of underground cavities using FEM - A Case	Training Programme on "Application of Finite Element Analysis for Water Resources Structures" organized by NWA, Pune at NWA, Pune	6-16 December 2010	Dhawan K.R. (Dr.), CRO
30.	Application of FEM in Analysis of Dams - A case study	Training Programme on "Application of Finite Element Analysis for Water Resources Structures" organized by NWA, Pune at NWA, Pune	6-16 December 2010	Pattanur L.R. (Dr.) (Ms),
31.	Application of FEM in Dynamic Analysis of Dams	Training Programme on "Application of Finite Element Analysis for Water Resources Structures" organized by NWA, Pune at NWA, Pune	6-16 December 2010	Pattanur L.R. (Dr.) (Ms),
32.	Dam Analysis using FEM	Training Programme on "Application of Finite Element Analysis for Water Resources Structures" organized by NWA, Pune at NWA, Pune	6-16 December 2010	Pattanur L.R. (Dr.) (Ms),
33	Application of FEM in coastal hydrodynamics	Training Programme on "Application of Finite Element Analysis for Water Resources Structures" organized by NWA, Pune at NWA, Pune	6-16 December 2010	Purohit A.A., SRO
34.	Application of FEM in Dynamic Analysis of Dams - A Case	Training Programme on "Application of Finite Element Analysis for Water Resources Structures" organized by NWA, Pune at NWA, Pune	6-16 December 2010	Rizwan Ali, SRO
35.	Importance of Model Studies in Design of dams Plus case studies on refinement of design	Training Programme on “Analysis and Design of Dams” organized by NWA, Pune at NWA, Pune	1 February 2011	Bhosekar V.V. (Mrs.), CRO

36.	Improvement in sediment management based on model studies	Training Programme on "Analysis and Design of Dams" organized by NWA, Pune at NWA, Pune	1 February 2011	Neena Isaac (Mrs.), SRO
37.	Assessment of liquefaction potential of foundation soils of dams	Training Programme on "Analysis and Design of Dams" organized by NWA, Pune at NWA, Pune	8 February 2011	Gupta R.P., CRO
38.	Reservoir Sedimentation Studies for predicting the life of Reservoir	Training Programme on "Analysis and Design of Dams" organized by NWA, Pune at NWA, Pune	9 February 2011	Roman U.C., SRO
39.	Seepage control measures in Dams	Training Programme on "Analysis and Design of Dams" organized by NWA, Pune at NWA, Pune	9 February 2011	Desai V.T., SRO
40.	Alkali-aggregate reaction in concrete: preventive measures and rehabilitation	Training Programme on "Analysis and Design of Dams" organized by NWA, Pune at NWA, Pune	10 February 2011	Desai V.T., SRO
41.	Dynamic Analysis of Gravity Dams including Case Studies	Training Programme on "Analysis and Design of Dams" organized by NWA, Pune at NWA, Pune	11 February 2011	Rizwan Ali, SRO
42.	Stability Analysis of Gravity Dams under Seismic Loads Pseudostatic approach including Two Case Studies	Training Programme on "Analysis and Design of Dams" organized by NWA, Pune at NWA, Pune	11 February 2011	Rizwan Ali, SRO
43.	Recent Advances in Numerical Modelling of Ports and Harbour Engineering Problems: Global scenario and state of art	National Workshop on "Environment, Dams and Ports" organized by VPDU, ISH, CWPRS at Bharti Vidyapeeth Engg. College, Pune	15-16 February 2011	Singh C.B. (Dr.), JD

44.	Advanced modeling Techniques and water quality aspects of high head structures	National Workshop on "Environment, Dams and Ports" organized by VPDU, ISH, CWPRS at Bharti Vidyapeeth Engineering College, Pune	15-16 February 2011	Bhajantri M.R. (Dr.), SRO
45.	Impact of Port development on the coastline and need for protections.	National Workshop on "Environment, Dams and Ports" organized by VPDU, ISH, CWPRS at Bharti Vidyapeeth Engineering College, Pune	15-16 February 2011	Kudale M.D., JD
46.	Modelling Techniques for Ports Planning and Development	National Workshop on "Environment, Dams and Ports" organized by VPDU, ISH, CWPRS at Bharti Vidyapeeth Engineering College, Pune	15-16 February 2011	T Nagendra, CRO
47.	GPS Communication and Flow Control System	Workshop on "Advanced Control and Automation"	25 February 2011	M. Selva Balan, SRO
48.	Overview of River Monitoring Network	Work Shop on the Purpose Driven Study (PDS) "Optimization of gauge discharge station and rain gauge network in Maharashtra"	28 February 2011	Jagtap R.S,SRO
49.	Optimization of Rainfall Network in Upper Bhima basin using Spatial Correlation Analysis and by Entropy method	Work Shop on the Purpose Driven Study (PDS) "Optimization of gauge discharge station and rain gauge network in Maharashtra"	20 February 2011	Roy S.K. (Dr.),CRO Jagtap R.S,SRO
50.	Spatial Hydrologic Regression using Generalized Least Squares Method	Work Shop on the Purpose Driven Study (PDS) "Optimization of gauge discharge station and rain gauge network in Maharashtra"	28 February 2011	Jagtap R.S,SRO

51.	Optimization of Hydrometric (GD) Network for Upper Bhima using empirical and analytical approaches	Work Shop on the Purpose Driven Study (PDS) "Optimization of gauge discharge station and rain gauge network in Maharashtra"	28 February 2011	Jagtap R. S. ,SRO
52.	Water Quality Modelling for Sardar Sarovar: A Case Study	Training Program on " Water Quality Management (Surface Water)	7-16 March 2011	Vaidya S.P. (Mrs.) (Dr.),CRO
53.	Extreme Wave Analysis	Sinhgad College of Engineering for M.E (Civil-Hydraulics) Students	25 March 2011	Kudale M.D,JD

CONTRIBUTIONS TO BIS AND ISO STANDARDS

New ISO Standards Drafted

1. ISO 6421 Hydrometry – Methods for assessment of reservoir sedimentation
2. ISO NP/11651 Reservoir Sedimentation – Estimation of sediment deposition in reservoir using Simulation Models
3. ISO/WD 11657 Flow measurement in open channels – Determination of calibration by Surrogate Techniques – Sedimentation in streams and canals

ISO Standards Reviewed

1. ISO 748:2007 "Hydrometry - Measurement of liquid flow in open channels using current-meters or floats"
2. ISO/FDIS 772: Hydrometry – Vocabulary and Symbols
3. ISO1100-1:1996 Measurement of liquid flow in open channels – Part 1 Establishment and Operation of a gauging station
4. ISO/FDIS 1100-2: Hydrometry - Measurement of liquid flow in open channels – Part 2: Determination of the stage-discharge relation
5. ISO 3846:2008 "Liquid flow measurement in open channels by weirs and flumes – Rectangular broad-crested weirs"
6. ISO 4359: Liquid flow measurement in open channels – Rectangular, Trapezoidal and U-shaped flumes
7. ISO 4360:2008 "Liquid flow measurement in open channels by weirs and flumes – Triangular profile weirs"
8. ISO 4364:1997 Measurement of liquid flow in open channels -- Bed material sampling
9. ISO 4377 Hydrometric determinations - Liquid flow measurement in open channels using structures – Flat V Weirs
10. ISO 9195:1992 Liquid flow measurement in open channels -- Sampling and analysis of gravel-bed material ISO/TS 3716:2006
11. ISO 9196: Liquid flow measurement in open channels -- Flow measurements under ice conditions
12. ISO 9555 (Part 1-4): Dilution Methods
13. Hydrometry – Functional requirements and characteristics of suspended sediment samplers

Review of ISO Standards for Adoption as BIS Standards

1. Doc. WRD1(499) Hydrometry - Measurement of Liquid Flow in Open Channels using Current Meters or Floats (Revision of IS 1192 and Adoption of ISO 748:2007)
2. Doc. WRD1(529) Requirements for rotating element current meters (cup type) for water flow measurement (Revision of IS 3910 and based on ISO 2537:2007)
3. Doc. WRD1(533) Sounding rods - Functional requirements (Revision of IS 3912 and based on ISO 3454:2008)

4. Doc. WRD1(531) Methods for measurement of suspended sediment in open channels (Revision of IS 4890 and based on ISO 4363:2002)
5. Doc. WRD1(528) Guidelines for the selection of flow gauging (Revision of IS 12752 and based on ISO 8368:1999)
6. Doc. WRD1(532) Liquid flow measurement in open channels using thin plate weirs (Revision of IS 9108 and based on ISO 1438:2008)
7. Measurement of liquid flow in open channels - Method of measurement of bed load discharge (Revision of IS 1192 and Based on ISO/TR 9212:1992)
8. Specification for suspended sediment load samplers (Revision of IS 3913 and based on ISO/TS 3716 2006)
9. Measurement of liquid flow in open channels - Method of specifying performance of hydrometric equipment (Adoption of ISO 11655:1995)
10. Measurement of liquid flow in open channels – Design, selection and use of electromagnetic current meters (Based on ISO/ TS 15768:2000)
11. IS 13371:1992 Adoption of ISO 3455:2007 Code of Practice for calibration (rating) of rotating element current meters in straight open tank
12. IS 14359:1996 ISO 4366:2007 Echo sounders for water depth measurements
13. IS 14974:2001 ISO 3846:2008.Liquid flow measurement in open channels by weirs and flumes - Rectangular broad-crested weirs
14. IS 15772:2008 ISO 9825:2005 Measurement of liquid flow in open channels - Field measurement of discharge in large rivers and floods

Indian Delegation at 27th Meeting of ISO TC 113 Hydrometry, 18th –22nd October 2010, Portland, Oregon, USA

PARTICIPATION IN MEETINGS OF TECHNICAL COMMITTEES

No.	Name of Committee	Date and Venue	Participant(s)
1.	Standing committee of experts on Majuli Island to review and suggest suitable measures for protection of Majuli Island	10-11 April 2010 Guwahati	M.N. Singh, CRO
2.	63rd TAC meeting for discussions on the RRM scheme for improvement of drafts in Hugli Estuary	22 April 2010 Kolkatta	P.K. Khare, JD T. Nagendra, CRO
3.	5th Meeting of Specification Committee under HP-II	10 May 2010 CWC, New Delhi	B. Vijay Kumar, J.D.
4.	16th Kosi Barrage Gate Regulation Committee Meeting	11-13 May 2010 Birpur, Bihar	Anil Babu Porika, R.O.
5.	64th Gate Regulation Committee Meeting of Farakka Barrage Project	19 May 2010 Farakka	Arun Kumar, R.O.
6.	Meeting for Revision of CBIP Publication No. 204 on "River Behavior Management"	June 2010 New Delhi	U.C. Roman, SRO
7.	Environmental Appraisal Committee (EAC) for Airport at Navi Mumbai (Safe grade elevation)	21 July 2010 New Delhi	V.G. Bhave, CRO
8.	Meeting on a comprehensive assessment of the erosion in the area of Dholla-Hatighuli, Nagaghuli and Rohmoria near Dibrugarh on river Brahmaputra	10 July 2010 Dibrugarh	M. K. Pawar, CRO
9.	Meeting of the Steering Committee for the Hydrology Unit, MMRDA	18 August 2010 CWPRS, Pune	T. Nagendra, CRO
10.	Environmental Appraisal Committee (EAC) meeting for clearance of RGPPL Dabhol project, Maharashtra (underwater rock dredging in approach channel)	19 August 2010 New Delhi	G.R. Tripathi (Dr.), RO
11.	TAC Committee meeting on RRM of Hugli River	22 September 2010 CWPRS, Pune	M. D. Kudale, JD A. S. Barve, CRO V. K. Shukla, RO
12.	6th Meeting of Specification committee under Hydrology Project II	30 September 2010 New Delhi	B. Vijaykumar, JD
13.	Group Meetings of ISO TC 113 on Hydrometry	18-22 October 2010 Portland, USA	I. D. Gupta (Dr.), Director
14.	Kosi High level Committee Meeting	19-22 November 2010, Birpur, Bihar	M.N. Singh, CRO Anil Babu Porika, RO

15.	43rd meeting/ inspection visit of Gandak High Level Standing Committee	03-05 December 2010 Lucknow & Gorakhpur	V.G. Bhave, CRO
16.	19th Meeting of Indian National Committee on Hydraulics (INCH)	11 January 2011 CWPRS, Pune	I. D. Gupta (Dr.), Director A.R. Chavan, JD
17.	106th Technical Advisory Committee Meeting (TAC) of Farakka Barrage Project	03-04 January 2011 Farakka	Arun Kumar, RO
18.	Meeting for Finalization of Guidelines for Site Specific Seismic Studies for River Valley Projects	02 February 2011 CWC, New Delhi	I.D. Gupta (Dr), Director
19.	4th Meeting on "Hydrological Information System Management Group HISMG (IS&T)"	31January 2011 and 01February 2011 New Delhi	F. T. Mathew, JD
20.	8th Meeting of "Hydrological Information System Management Group HISMG(T)"	31January 2011 and 01February 2011 New Delhi	F. T. Mathew, JD
21.	3rd Project Management Committee (PMC) Meeting of Fly Ash Mission	11 February 2011 MERI, Nasik	V. T. Desai, SRO A. V. Patil, RO
22.	13th Meeting of Sectional Committee WRD 16 on Hydraulic Structures Instrumentation	23 February 2011 BIS, New Delhi	Rizwan Ali, SRO
23.	Meeting of WRD 1 on Hydrometry	04 March 2011 BIS, New Delhi	I. D. Gupta (Dr.), Director R. G. Patil (Dr.), CRO
24.	20th Meeting of Indian National Committee on Hydraulics (INCH)	09 March 2011 CWPRS, Pune	I. D. Gupta (Dr.), Director A.R. Chavan, JD
25.	1st Meeting of AERB Committee on Safety of NPP – External Events (AERBSC-EE)	31 March 2011 AERB, Mumbai	I.D. Gupta (Dr.), Director

Meeting of Steering Committee for the Hydrology Unit, MMRDA held at CWPRS on 18th August 2010

Meeting of 67th Dam Safety Panel for Anjunem Dam, Goa held at CWPRS on 20th August 2010

19th INCH Meeting held at CWPRS on 11th January 2011

GENERAL

BUDGET AND FINANCE

1. Plan Schemes

The main purpose of Plan Schemes is to develop and strengthen the research infrastructure at CWPRS for serving the nation through research more efficiently and effectively. The following schemes were under implementation at the institution during 2010-11.

No.	Name of the scheme	Final Estimate 2010-11 (lakh)
A)	XIth Plan - R&D in Apex Organizations under MoWR– CWPRS component	577.72
B)	Hydrology Project II	125.00

During 2010-11, the following important activities were undertaken under the above-mentioned schemes.

A) XIth Plan - R&D in Apex Organizations under MoWR– CWPRS Component

- Civil Works: Modernization of existing Auditorium; Hanger for Multipurpose Wave Basin for design of Port Layout; Up-rating of LT supply cable at Multipurpose Wave Basin; Repair and widening of roads; Water-proofing of various Laboratory cum Office Buildings

- Machinery & Equipment: Instrumentation of Multipurpose Wave Basin, Nx-size Rock Core Cutting machine, Nx-size Rock Core Polishing machine, Strain gauges and digital dial gauges, Concrete Resistivity Meter, Electro-Dynamic Shaker, Impact-Echo Test System, 4-Channel Blast Vibration Recorder;, PC-based FEM software for structural analysis; Water Purification System; Dynamometer/ proving rings, Adhesion tester; Electronic Extensometers for measurement of Modulus/ Poisson's ratio/ toughness; Radar Sensor

- Information & Communication Technology: Server with Windows 2008 Operating System, Modernization of Data Center and relocating existing Server Network setup Personal Computers (34), 70-Watt Amplifier and related sound equipment

B) Hydrology Project II

- Procurement of machinery & equipment for upgradation of Current Meter Rating Trolley; Procurement of HP Model Z-200 Workstation and ESRI ArcGIS products ArcInfo, 3D Analyst, Spatial Analyst & Geostatistical Analyst; Computers and peripherals; Training of CWPRS personnel on topics of: Decision Support System for water resources planning and management, and procurement procedures & financial management; Civil works for modernization of Library building of CWPRS and modernization of VIP Guest House at CWPRS

- A purpose driven study entitled `Optimization of gauge-discharge network in Upper Bhima basin up to Ujjani' was completed during 2010-2011 jointly with the Water Resources Department, Government of Maharashtra. A technical report on the study was submitted to MoWR and Govt. of Maharashtra in December 2010

- Under HP-II, a 3-day course on 'Application of Statistical methods in hydrology' was organized by CWPRS at Pune during 19-21 October 2010; wherein 21 officials from implementing Agencies of the project were trained.

- CWPRS in association with PWD, Goa, conducted a course on 'Calibration of current meters and their usage in rivers' at Goa; wherein 35 officials of Goa were trained

2. Non-Plan Budget

The non-plan budget and expenditure details for the year 2010-11 are given below.

Item/ Head	2010-11 (Rs. Crore)			
	Budget Estimate	Revised Estimate	Final Estimate	Actual
Salary	30.00	37.11	39.60	39.60
Non-Salary	1.97	2.44	2.61	2.59
Total (Gross)	31.97	39.55	42.21	42.19
Recovery	6.50	6.50	6.50	9.62
Net	25.47	33.05	33.71	32.57

STAFF WELFARE ACTIVITIES

1. Minority Welfare

The recruitment of personnel from minority community, and representation of minorities in Selection Committees/ Boards is monitored in accordance with guidelines issued by the erstwhile Ministry of Welfare (present Ministry of Social Justice & Empowerment) in March 1990 in the respect.

2. Monitoring of Reservation for Physically Handicapped

Monitoring of the recruitment of physically handicapped persons is being done to ensure fulfillment of three percent quota, as stipulated. At present, a total of 33 persons with disabilities are working in the Research Station with 3, 7 and 23 in group A, B and C, respectively. Benefits earmarked like Transport Allowance, Concessions regarding Recruitment fees, Professional Tax exemptions etc. are provided as per Government instructions. Slope ladders and special washrooms are being provided in the Research Station wherever possible.

3. Monitoring of Reservation for SC/ ST/ OBC

Monitoring of the recruitment of candidates from SC/ST/OBC category is made following the guidelines issued from time to time. Shri R.K. Kamble, Chief Research Officer, guides the overall matters in this regard as Liaison Officer. A summary of posts filled from SC/ST/OBC/PH categories are given below.

Group	Position as on 31st March 2011				
	SC	ST	OBC	PH	UR
A	21	6	12	3	97
B	38	10	21	7	172
C	104	45	24	23	383
Total	163	61	57	33	652

4. Preservation and Enforcement of Right to Gender Equality of Working Women

There are five-members in the committee for preservation and enforcement of right to gender equality of working women; with the composition of the committee as per the guidelines issued by the Honourable Supreme Court of India. Meetings of the committee are held regularly. One complaint was received, and the same was disposed off by the committee during 2010-11.

5. Colony Welfare Committee

CWPRS colony welfare committee is actively engaged in various activities welfare for colony residents. Some important activities done by welfare committee during the period 2010-2011 are as follows:

- Independence Day is celebrated by colony welfare committee and organized games, drawing and cultural programs
- On the occasion of Sabhavana Diwas a drawing /painting competition has been organized for colony children

- Ganesha festival is celebrated with full spirit and devotion by colony residents and various programs like Rangoli competition for ladies, Antakshari and Fancy dress show was organized

- Republic Day is celebrated by colony welfare committee and organized games, drawing and cultural programs. On this occasion food festival is also organized and different regional foods are presented by colony residents. People enjoyed this food festival

- Colony welfare committee is working as a bridge between Office and colony for development of colony.

Glimpses of Cultural Program Organized on the Independence Day in Colony

Flag Hoisting by Dr. I.D. Gupta, Director, CWPRS, on Republic Day 2010 in Staff Colony

Tree Plantation in Staff Colony Area

6. Recreation Club Activity

CWPRS Recreation Club has been actively engaged in various recreational activities for the employees in the office as well as in colony campus. The major activities undertaken by Recreation Club during the period 2010-11 are as follows:

- Lecture on "Water is life" by Shri Rajendra Aswale, Chief Administrative Officer, CWPRS was arranged
- On the occasion of Navratri, folk dance programme was performed by ladies of recreation club
- Picnic to Sajangad and Karla Caves gave the employees an opportunity of natural site seeing
- Health has always been an important area of concern for Recreation Club. Lecture on Bach medicines by Dr. Tanuja Jawdekar was arranged. A lecture on avoiding the heart diseases by Dr. Jagdish Hiremath was also organized
- Food festival was also an activity undertaken by the Recreation Club in which many officials took part and enjoyed the food of different states
- Sports events organized by Recreation Club gives lot of opportunity to the employees for participating in different sport activities

Dr. I.D. Gupta, Director, Welcoming Dr. Jagdish Hiremath, a Renowned Cardiologist of Pune during his visit to CWPRS for delivering Lecture on "My Heart and Ourselves"

VIGILANCE AND DISCIPLINARY CASES

The vigilance / disciplinary cases, and related complaints concerning officers and staff of CWPRS, received prompt attention during 2010-11. Break-up of vigilance and disciplinary cases in respect of different categories of staff, as on 31st Mar 2011, is given below in Tables I and II respectively.

Table I: Vigilance cases

No.	Particulars	Group A	Group B	Group C
1	No. of cases pending in the beginning of the year	0	0	0
2	No. of cases added during the year	0	0	0
3	No. of cases disposed off during the year	0	0	0
4	No. of cases pending at the end of the year	0	0	0

Table II: Disciplinary cases where the Director, CWPRS is the disciplinary authority

No.	Particulars	Group A	Group B	Group C
1	No. of cases pending in the beginning of the year	0	1	0
2	No. of cases added during the year	0	1	2
3	No. of cases disposed off during the year	0	1	0
4	No. of cases pending at the end of the year.	0	1	2

Vigilance Awareness Week Celebrations at CWPRS

RTI ACT, GRIEVANCE REDRESSAL MECHANISM AND CITIZEN'S CHARTER

1. RTI Act

Under the provisions of Section 4 (b) of RTI Act 2005, manual giving suo - moto information on CWPRS has been published in the Website www.cwprs.gov.in as a part of implementation of the act. The manual is periodically being updated. Further, all efforts are being taken to administer and implement the act. The citizens are also given guidance in obtaining information under the act. The names, addresses and other details regarding the Appellate Authority and Public Information Officer are given below.

Appellate Authority: Dr. I.D. Gupta, Director, CWPRS, Pune 411024;
Tel.: 020-24380552 (Office); 020-24348917 (Residence)

Public Information Officer: F. T. Mathew, Joint Director, CWPRS, Pune 411024;
Tel: 020-24103211 (Office); 020- 25888307 (Residence)

Information on requests and appeals handled under the act during 2010-11 is summarized below:

	Opening balance (as on 1st Apr 2010)	Received during the year (including cases transferred to other Public Authorities)	No. of cases transferred to other Public Authorities	Decisions where requests/ appeals rejected	Decisions where requests/ appeals accepted
Requests	2	28	1	3	23
First Appeal	0	3	0	2	1
Charges Collected (Rs.)					
Registration fee	Additional fee & other charges				Penalty
190	2,592				0

2. Grievance Redress Mechanism

A Grievance Cell under the chairmanship of Shri B. Vijayakumar, Joint Director, functions with the objective of looking into the grievances and for their redressal. The relevant data pertaining to cases handled during 2010-11 is given below:

Grievance cases pending as on 31st March 2010	1
Cases received during 2010-11	9
Cases disposed off during the year	8
Cases pending on 31st March 2011	2

The Centralised Public Grievance Redress and Monitoring System (CPGRAMS), the web based portal that enables an Indian citizen to lodge a complaint from anywhere and anytime directly, has been implemented at CWPRS. Periodical updating of the entries are being carried out and relevant reports submitted.

3. Citizen's Charter

The Citizen's Charter in respect of CWPRS, formulated by a Task Force specially constituted for the purpose, has been subsequently upgraded/ revised/ modified in pursuance of related instructions/ communications from the Ministry from time to time, including the 7- step model for `Sevottam for Citizen Centricity in administration' as per relevant instructions of DARPG. The main components of the Citizen's Charter include: Vision and mission statement, details of business transacted and customers/ clients, services provided by the organisation, details of grievances redress mechanism in place and expectations from clients. Presently the Charter is in the process of getting formal approval from MoWR.

IMPORTANT VISITORS

Shri U.N. Panjiar, Secretary, MoWR and Shri Shaikh Md. Wahid-Uz-Zaman, Secretary, Water Resources, Bangladesh, at Kotlibhel Spillway Model during their visit to CWPRS on 5th June 2010

Visit of Capt. P.V.K. Mohan, Chairman, National Shipping Board, to Current Meter Calibration Facility at CWPRS on 27th August 2010

Shri Sudhir Garg, Joint Secretary, MoWR at the Hydraulic Model of River Yamuna at Delhi, during his visit to CWPRS on 28th January 2011

Hon'ble Union Minister for Water Resources and Minority Affairs, Shri Salman Khurshid and Hon'ble Minister of State for Water Resources and Minority Affairs, Shri Vincent H. Pala at Kosi River Model during their visit to CWPRS, Pune on 30th March 2011

राजभाषा हिन्दी के प्रगामी प्रयोग से संबंधीत प्रमुख गतिविधियाँ

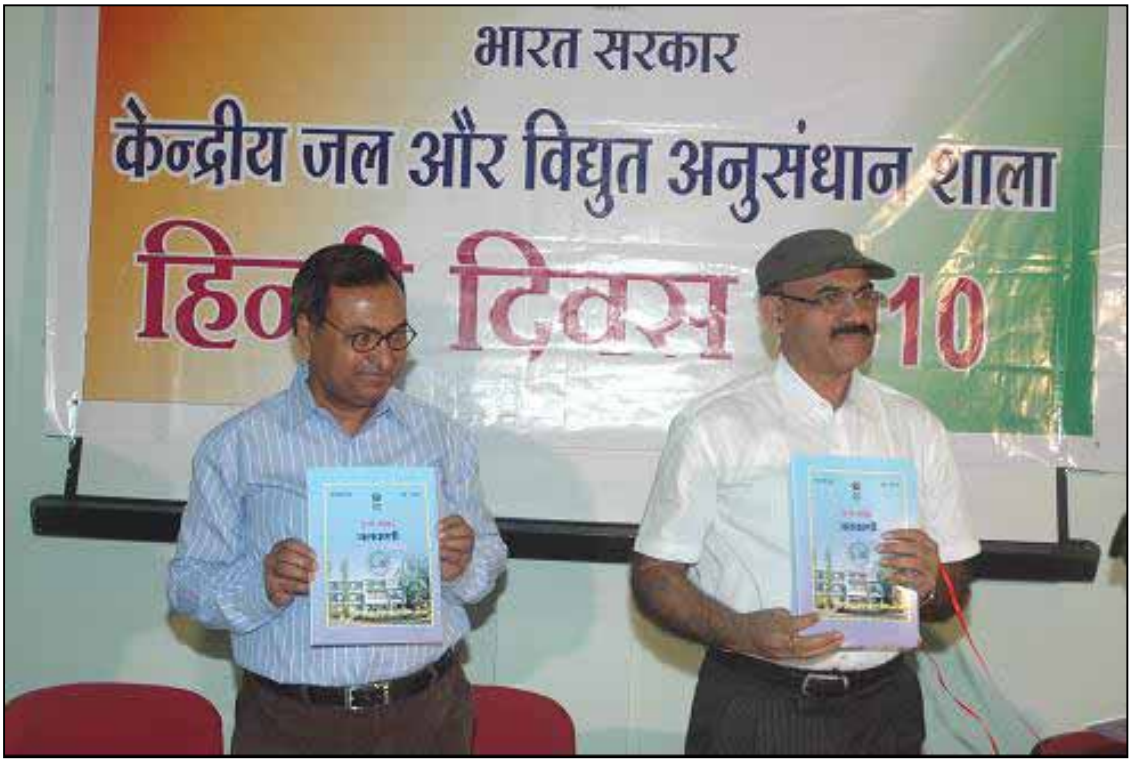
इस अनुसंधान शाला में कार्यालयीन कामकाज में हिंदी के प्रगामी प्रयोग से संबंधीत गतिविधियों के बारे में निम्नानुसार जानकारी प्रस्तुत है :

हिंदी दिवस तथा हिंदी पखवाड़ा

अनुसंधान शाला में 14 सितम्बर 2010 को हिंदी दिवस मनाया गया । इस अवसर पर महाराष्ट्र के बिक्रीकर उपायुक्त श्री माणिक मुंडे, मुख्य अतिथि के नाते उपस्थित थे । हिंदी पखवाड़े के दौरान राजभाषा कार्यान्वयन समिति के मार्गदर्शन में हिंदी निबंध, वाद-विवाद, वार्तालाप, प्रश्न-मंच, प्रस्तुतीकरण, हिंदी टंकण तथा तकनीकी कार्य में हिंदी का प्रयोग आदि प्रतियोगिताओं का आयोजन किया गया। इन प्रतियोगिताओं में अधिकारी एवं कर्मचारी उत्साह से सम्मिलित हुए। भारत सरकार द्वारा लागू मूल रूप में हिंदी में टिप्पण आलेखन पुरस्कार योजना अनुसंधान शाला में लागू की गई थी। इन प्रतियोगिताओं में योग्यता प्राप्त अधिकारी एवं कर्मचारियों को मुख्य अतिथि के करकमलों द्वारा नकद पुरस्कार एवं प्रमाणपत्र देकर प्रोत्साहित किया गया ।

हिंदी पत्रिका जलवाणी का प्रकाशन

हिंदी दिवस के अवसर पर मुख्य अतिथि श्री माणिक मुंडे, बिक्रीकर आयुक्त, महाराष्ट्र, के करकमलों द्वारा अनुसंधान शाला की हिंदी गृह पत्रिका जलवाणी के सत्रहवें अंक का प्रकाशन किया गया । इस अनुसंधान शाला के अधिकारियों/कर्मचारियों ने उक्त पत्रिका में लेख भेजकर योगदान दिया है ।



हिन्दी दिवस 2010 के मुख्य अतिथि श्री माणिक मुंडे, बिक्रीकर आयुक्त, महाराष्ट्र, के करकमलों द्वारा हिंदी गृह पत्रिका जलवाणी के सत्रहवें अंक का प्रकाशन, 14 सितंबर 2010

हिंदी कार्यशालाओं का आयोजन

वार्षिक कार्यक्रम में दिए गए निदेशों के अनुसार अनुसंधान शाला में निम्नांकित तारीखों को हिन्दी कार्यशालाएँ आयोजित की गई :

अ.क्र.	अवधि	श्रेणी	अधिकारियों संख्या
1.	23 जून 2010	मुख्य अनुसंधान अधिकारी - 14	14
2.	24-25 मार्च 2011	मुख्य अनुसंधान अधिकारी - 09 वरिष्ठ अनुसंधान अधिकारी - 11	20

संघ की राजभाषा नीति, सरकारी पत्राचार के नमूने, टिप्पण-आलेखन एवं भाषा और वर्तनी के बारे में उपयोगी सामग्री प्रशिक्षण कार्यक्रम में सम्मिलित थी। उपस्थित सभी प्रतिभागियों को हिन्दी कार्यशाला नामक पुस्तिका वितरित की गई। जिसमें कार्यालयीन उपयोग से संबंधित जानकारी जैसे वाक्यांश, पदनाम, नेमी किस्म के पत्रों के नमूने, छुट्टी के आवेदन आदि । उपस्थित प्रतिभागियों ने कार्यशाला की उपयुक्तता के बारे में अपनी अनुक्रिया (फीड बैक) प्रस्तुत की ।

हिन्दी कार्यशाला के उद्घाटन के अवसर पर प्रतिभागियों को संबोधित करते हुए डॉ. आई.डी. गुप्ता, निदेशक

कंप्यूटरों में हिंदी साफ्टवेयर

अनुसंधान शाला के सभी संगणकों हिन्दी सॉफ्टवेयर लगवाए गए हैं जैसे iLeap, ISM Office, ISM Publisher और iTranslator इत्यादि । अनुसंधान शाला के कुल 78 अधिकारी एवं कर्मचारियों को iTranslator इस्तेमाल करने संबंधी प्रशिक्षण दिलाया जा चुका है।

हिंदी वेबसाइट

इस अनुसंधान शाला की वेबसाइट www.cwprs.gov.in बनाई गई है जिसमें संस्था के बारे में जानकारी हिंदी में उपलब्ध कराई गई है। इसे समय-समय पर अद्यतन किया जाता है ।

अनुसंधान शाला के इन्ट्रानेट पर हिन्दी में नेमी प्रपत्र /मानक मसौदे उपलब्ध कराना

प्रतिदिन काम आनेवाले नेमी किस्म के प्रपत्र, मानक मसौदे जैसे आकस्मिक छुट्टी के आवेदन, कार्यग्रहण रिपोर्ट, प्रस्थान रिपोर्ट, प्रभागों/अनुभागों के नाम, मंत्रालयों/विभागों के नाम, छुट्टियों के प्रकार, वर्तनी, संदेश, गृह पत्रिका जलवाणी का सोलहवाँ अंक, हमेशा प्रयुक्त होने वाले वाक्यांश आदि हिन्दी में उपलब्ध कराए गए हैं । साथ ही अनुसंधान शाला द्वारा 10 प्रयोगशालाओं की तकनीकी अंग्रेजी-हिन्दी शब्दावली भी उपलब्ध कराई गई है ।

हिन्दी पुस्तकों की खरीद

अनुसंधान शाला के पुस्तकालय में वर्ष 2010-2011 के दौरान जर्नल और मानक ग्रंथों की खरीद पर हुए व्यय को छोड़कर कुल रू. 13,643.00 की हिन्दी पुस्तकें खरीदी गई ।

नियम 8(4) के अधीन हिन्दी में कामकाज

अनुसंधान शाला के 10 अधिकारियों/कर्मचारियों को राजभाषा नियम 1976 के नियम 8(4) के अधीन टिप्पण प्रारूपण और ऐसे अन्य शासकीय प्रयोजनों के लिए केवल हिन्दी का प्रयोग करने के लिए दिनांक 14.8.2003 के आदेश संख्या 675/6/2003-हिन्दी द्वारा नामित किया गया है ।

तकनीकी काम में हिन्दी का प्रयोग

अनुसंधान शाला के विभिन्न प्रभागों/अनुभागों द्वारा किए जाने वाले अध्ययनों के आधार पर परियोजना प्राधिकारियों को भेजे जाने वाले तकनीकी रिपोर्टो के सारांश, अग्रेषण पत्र, रिपोर्ट प्रलेख पत्र, सार, प्राक्कलन, विषय सूची आदि मदे अंग्रेजी के साथ अनिवार्यत: हिन्दी में भी भेजने हेतु अनुरोध किया गया है।

Interaction by Dr. I.D. Gupta, Director with Prof. D.N. Singh, IIT Bombay along with Ph.D. Students

Interaction by Dr. I.D. Gupta, Director with Senior Officers of CWPRS

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