

## **Minutes of the tenth National Committee on Dam Safety meeting held on 24.2.1993 at Central Water Commission, New Delhi.**

The tenth meeting of the National Committee on Dam Safety (NCDS) was held on 24 February 1993 at Sewa Bhavan, R.K.Puram, New Delhi under the Chairmanship of Shri M.S.Reddy, Chairman, CWC, and Chairman of NCDS.

The list of officers who attended the meeting is given in Annex I.

Shri M.S.Reddy, Chairman, NCDS welcomed the members of NCDS and other participants. The items on the agenda of the tenth meeting were taken up for discussion.

### **10.1 Confirmation of the minutes of the ninth meeting.**

- 10.1.1 The minutes of ninth meeting were circulated to all the members of NCDS, participants and the State Dam Safety Cells vide Letter No.3/19/NCDS/92-DS/692-741 dated 6.8.92. Comments were received from some States. After discussion, it was felt that there was no need to change the minutes as recorded, which were, therefore, confirmed.

### **10.2 "Dam Safety Assurance and Rehabilitation Project"**

- 10.2.1 As a matter of providing information to the members of NCDS, Director (Dam Safety), CWC narrated the activities that took place in the process of implementation of the DSARP touching on the key issues of institutional strengthening, provision of basic facilities to selected dams, meetings of the Dam Safety Review Panels (DSRP), undertaking Phase I inspection of large dams and conducting workshops by the States on Dam Safety.
- 10.2.2 Institutional strengthening of the four participating States (Madhya Pradesh, Orissa, Rajasthan & Tamil Nadu) for the first phase has already taken place. CWC has already allocated staff and officers for this project at the commencement of 1992.
- 10.2.3 The participating States have already identified dams for providing basic facilities (roads, wireless sets, hydrometeorological observation gadgets, dam instruments, etc.) and have prepared estimates for their procurement and execution of works.
- 10.2.4 By now, the Dam Safety Review Panels have met several times in all the four States and have examined the distress in all the

33 dams identified for rehabilitation. The States have also taken up rehabilitation measures of immediate nature for some dams with the approval of DSRP and CWC. In this respect, CWC have been retained as consultants for Parvati dam and Kota Barrage in Rajasthan. Government of Orissa have arranged the services of an overseas material specialist for a second opinion on the problem concerning the distress of Hirakud dam and the specialist Mr. David Stark from USA visited the Hirakud dam on the last week of January 1993. He held discussions on the problem of alkali-silica reactions concerning Hirakud dam with members of the Orissa Dam Safety Review Panel and also with members of the Hirakud Dam Crack Review Panel. He also delivered a lecture on the mechanism of alkali silica reaction in hydraulic structures at CWC on 28 January 1993 which was attended by a large number of officers from CWC, other organizations, State of Orissa and the World Bank.

- 10.2.5 The States have made substantial progress in undertaking Phase I inspection of large dams under their jurisdiction. CWC has already completed preparing one model Phase I inspection report of one large dam in each State which has formed the guideline for the States to undertake similar action for the rest of the dams.
- 10.2.6 The participating States in the DSARP have been regularly claiming reimbursement from the World Bank for expenditure incurred by them in the execution of activities covered by the project. It was noticed that the State of Orissa has been lagging behind in claiming reimbursement for the various activities conducted by them in the implementation of this project. It is essential for the State of Orissa to accelerate their reimbursement claim at the earliest to ensure maximum utilization of funds allocated to the project.
- 10.2.7 As regards holding of workshops on dam safety by the participating States, CWC had taken a lead by providing faculty members on the subjects of dam safety and hydrology. So far, workshops have been held in Tamil Nadu during August 1992 and in Orissa during October 1992. The workshops in Madhya Pradesh are scheduled some time by the end of March 1993 and in Rajasthan some time during April 1993.

### **10.3 Review of National Scenario.**

- 10.3.1 It has been customary for the member States of NCDS to intimate its members and participants fresh occurrences of

distress to dams, structural & operational deficiencies noted during post- and pre-monsoon inspections and also failure cases, if any.

- 10.3.2 No fresh cases of failure were reported by the States. Only Gujarat State had reported heavy leakages through masonry of Nyari dam and breaching of embankment in Chackha dam. These incidents occurred during the monsoon of 1992. Rehabilitation measures for these distressed structures have already been undertaken by the Gujarat State.
- 10.3.3 The State of Andhra Pradesh has yet to intimate to NCDS the reasons for dislocation of one crest gate at Kalyani dam which occurred during November 1991. This issue was discussed in the ninth meeting of NCDS. The State representative attending the meeting was requested to send a brief technical note of this problem for information of NCDS. Chairman, NCDS, observed that the States have been taking a lot of time in sending the technical reports of distress dams and failure cases, etc., to the Secretariat of NCDS. He requested all members to report expeditiously on distress and failure cases noticed by them for the general information of members of NCDS. He also mentioned the over-topping of the Kallada dam some time in October 1992 which has not been reported. Members of NCDS were requested to bring to the notice of NCDS even those cases of unusual flood events which results in over-topping of dams even if the dam does not fail.

(Action : all the States / Organisations)

#### **10.4 Implementation of recommendations of the "Report on Dam Safety Procedures."**

- 10.4.1 The States had been taking action from time to time in implementing the recommendations contained in the chapters of the "Report on Dam Safety Procedures" circulated in 1987. In order to assess the progress made by the States in implementing the recommendations, the States were asked to send a copy of consolidated statement indicating their achievement on this issue and also to highlight those recommendations that the States found difficult to implement.
- 10.4.2 The States of Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Rajasthan and Tamil Nadu have sent reports on the attempts made by the States to implement certain important recommendations embodied in the "Report on Dam Safety

Procedures." The issues covered by each State concerned, action taken by them on key issues like strengthening of existing dam safety unit in the State, compilation of Operation & Maintenance Manuals for large dams, preparation of completion report for existing dams and safety review of large dams which are more than 15 mt. in height or which store 50000 acre ft. or more of water by an independent panel of experts once in ten years.

- 10.4.3 The replies sent by the States indicate the difficulties have been faced by them in undertaking safety review of large dams by an independent panel of experts once in ten years. Only the State of Maharashtra which has 624 dams in the State which qualify for such a review has completed this job for ten major dams which had developed distress. There is a general misconception regarding deployment of an independent panel of experts. The States had presumed that these experts are supposed to be from States other than the State for which review is being conducted. The Chairman, NCDS clarified that the term "independent panel of experts" indicates that the members of the panel should be those who were not connected with the construction, operation and maintenance of these dams. There is no embargo in the deployment of experts from the same States. He requested the member States to prepare a programme for undertaking independent review of all the large dams in the State commencing with dams of National Importance and send the programme to the Secretariat of NCDS expeditiously.

(Action : all the States / Organisations)

**10.5 Review of dam safety activities in India including status report on the health of dams.**

- 10.5.1 The States / Members of NCDS are required to send the status report on dam safety activities in their respective States, including health status of dams to DSO, CWC, regularly.

- 10.5.2 The following States / Organisations have sent reports for the period mentioned against each State:

- (a) Andhra Pradesh : Updated to December 1987.
- (b) BBMB : Updated to October 1992
- (c) Gujarat : Updated to December 1992

- (d) Karnataka : Updated to January 1992
- (e) Madhya Pradesh : Updated to December 1992
- (f) Maharashtra : Updated to December 1991 and  
till December 1992 under preparation
- (g) Orissa : Updated to January 1989
- (h) Tamil Nadu : Latest available for 1991
- (i) West Bengal : Latest available for 1991 (only  
Health status of dams in brief)
- (j) NHPC : The organization has submitted  
recently the status report for Salal dam.

10.5.3 Rest of the States were requested to send the information on dam safety activities in their States, including health status of large dams under their charge expeditiously.

10.5.4 Chairman, NCDS desired that all the member States and Organisations shall prepare an activity report encompassing all the activities carried out by their dam safety units annually and send the same to NCDS for information.

(All the States / Organisations)

## **10.6 Formation of sub-committee to monitor safety aspects of inter-State dams.**

10.6.1 Three sub-committees were set up during March 1990 to monitor safety aspects of inter-State dams in the pas Parambikulam Aliyar Project System (PAP), Mahanadi System and Subarnarekha System.

10.6.2 Two meetings of PAP System were held during October 1991 and July 1992 respectively. Parambikulam and Sholayar dams were inspected by the members of sub-committee during the first meeting. During the second meeting, five dams, viz. Tunnakkada, Peruvuripallam, Aliyar, Upper Nirar and Lower Nirar were inspected. Summary record of the meetings were circulated to the member States by the Member Secretary for the sub-committee to take necessary action.

10.6.3 The first sub-committee meeting for Subarnarekha System was held during September 1992. the meeting was attended by the

members / representatives from the States of Bihar and Orissa. The representatives from the State of West Bengal could not attend the meeting. The minutes of the meeting were circulated by the Member Secretary / Convener from the State of Orissa for compliance. The second meeting of the Subarnarekha System was held on 4 December 1992 in Bhubaneswar which was also attended by the State of West Bengal. The State of Madhya Pradesh informed in the meeting that the sub-committee meeting of Mahanadi System is proposed to be convened during March 1993. The members of the sub-committee are requested to ensure their participation and report the outcome of the meetings.

- 10.6.4 Chairman, NCDS desired that the lower riparian States are required to take initiative to convene meetings and to provide all facilities to member States to inspect the dams coming under the sub-committee.

(Action: Bihar, Kerala, Madhya Pradesh, Orissa, Tamil Nadu & West Bengal)

## **10.7 Compilation of "Data Books."**

- 10.7.1 As per the decision taken in the fourth meeting of NCDS, "Data Book" for dams of National Importance are to be prepared by States and sent to DSO / CWC for record.
- 10.7.2 The States of Andhra Pradesh, Bihar, BBMB, Gujarat, Karnataka, Madhya Pradesh, Maharashtra and Tamil Nadu have already undertaken preparation of "Data Books" for their National Importance dams and information have been received in this respect.
- 10.7.3 "Data Book" sent by Rajasthan on the eve of the tenth meeting is not in proper order. The States of Kerala, Orissa, Rajasthan, Uttar Pradesh and West Bengal are requested to prepare "Data Books" of National Importance and send to DSO / CWC.

(Action : Kerala, Orissa, Rajasthan, Uttar Pradesh & West Bengal)

## **10.8 Safety inspection of barrages.**

- 10.8.1 During the seventh meeting of NCDS, members were requested to take stock of total number of important barrages, in order to verify the list of barrages State-wise supplied by DSO / CWC and requested to fill up the prescribed proforma and send to DSO / CWC.

- 10.8.2 The States of Bihar and Rajasthan have not responded so far. These two States and the States of Karnataka and Uttar Pradesh who had supplied partial information were requested to supply the pending information to DSO / CWC to take stock of the situation and decide on the future course of action for the safety of barrages.

(Action : Bihar, Karnataka, Rajasthan & Uttar Pradesh)

## **10.9 Safety status of dams of National Importance.**

- 10.9.1 Out of the 43 dams of National Importance, information had been received only for 28 dams.
- 10.9.2 So far, no information has been received from the States of Kerala, Orissa, Rajasthan and Uttar Pradesh. Madhya Pradesh has not sent the status report of Gandhi Sagar dam. The status reports are to be sent in the specified proforma.
- 10.9.3 All the above States are requested to send the information expeditiously as the publication on the health status of National Importance dams proposed to be brought out by DSO / CWC is held up.

(Action : Kerala, Madhya Pradesh, Orissa, Rajasthan & Uttar Pradesh )

## **10.10 Dam Safety Legislation**

- 10.10.1 Out of 12 States, only 7 offered their comments on the draft bill on Dam Safety Legislation circulated to all the States. The issue was discussed several times in NCDS meetings and pursued by the Secretary, Ministry of Water Resources.
- 10.10.2 The five States, viz. Bihar, Karnataka, Maharashtra, Rajasthan & West Bengal have not yet responded. These State Governments may take an early decision on this issue without any further delay.

(Action : Bihar, Karnataka, Maharashtra, Rajasthan & West Bengal)

## **10.11 Safety review of large dams.**

- 10.11.1 As per recommendations of Dam Safety Procedures, safety review of dams which are more than 15 m in height or which store 60 million cubic metre or more of water, was to be carried

out by an independent panel of experts once in ten years. The proposal was accepted by Government of India in 1987 and as such review of all large dams is to be completed by 1997.

- 10.11.2 The States of Gujarat, Madhya Pradesh, Maharashtra, Orissa, Rajasthan & Tamil Nadu have responded in this matter. Out of 197 large dams proposed for inspection by Gujarat, 50 have been inspected upto December 1992. Madhya Pradesh & Maharashtra have drawn out a tentative programme for inspection of 120 and 12 dams respectively for the year 1992-93. Tamil Nadu has also given a programme for 1993-97 beginning from 1993 with inspection of 5 dams every year. Rajasthan has made programme for 124 dams for Phase I inspection by the State engineers and a programme for Phase I inspection for 1991-97 for 147 large dams has also been drawn by Orissa State and inspection for 40 dams has been completed.
- 10.11.3 Chairman, NCDS clarified that the independent panel of experts for safety review of dams need not be from outside the States. They may be deputed from the State itself. The States are requested to chalk out year-wise programme for inspection of large dams by independent panel of experts at the earliest.

(Action : All the States / Organisations)

**10.12 Undertaking Emergency Action Downstream and Demarcation of Flood zones.**

- 10.12.1 During the seventh meeting of NCDS, the States were requested to work out modalities for undertaking Emergency Action Plans for National Importance dam in their States. Subsequently, in the eighth meeting of NCDS, Chairman suggested that four States who were participating in the Dam Safety Assurance and Rehabilitation Project (DSARP), Madhya Pradesh, Orissa, Rajasthan & Tamil Nadu shall take up Emergency Action Planning of the 33 dams posed for rehabilitation.
- 10.12.2 A course on "Dam Break Analysis" was conducted by CWC in September 1992 at Hyderabad. Engineers from the States of Andhra Pradesh, Gujarat, Madhya Pradesh, Orissa, Tamil Nadu & West Bengal participated in this course whereas engineers from Rajasthan could not attend the course.
- 10.12.3 The replies on preparation of Emergency Action Plan on downstream and demarcation of flood zones have been received from the States of BBMB, Gujarat, Karnataka, Madhya Pradesh,



Maharashtra and Tamil Nadu. Engineers from Gujarat and Tamil Nadu informed that demarcation of flood zoning is not necessary in their States but Emergency Action Plans for dams of National Importance will be taken up by Tamil Nadu. Maharashtra had already prepared Emergency Action Plan for Koyna, Paithan and Ujjani dams and Karnataka had completed the job for Linganamakki dam. Engineers from BBMB informed that the preparation of Emergency Action Plan need to be taken up by the State of Punjab as the downstream area fall under the jurisdiction of Punjab State. In case of Madhya Pradesh, the proposal is still under consideration of the State Government.

- 10.12.4 Chairman, NCDS clarified that flood zoning plan given in the previous agenda may be read as inundation plan for dam break floods. The State Governments who have not yet responded are requested to intimate the progress achieved in this respect at the earliest.

(Action : All the States)

### **10.13 National Register of Large Dams**

- 10.13.1 A publication titled "National Register of Large Dams" was circulated to the representatives from the States for examining the register and indicating corrections / modifications / additions, if any.
- 10.13.2 Necessary corrections had already been undertaken in the computerized data on the basis of information received from the States. In the meeting, representative from Rajasthan informed that the information will be furnished by the end of March 1993. Orissa has not responded so far. Authorities of the above States are requested to update the data and inform DSO / CWC as early as possible so that the "National Register of Large Dams" may be reprinted with the revised data supplied by the States.

(Action : Orissa & Rajasthan)

### **10.14 Setting up of hydrological unit in the States for review of hydrology of existing dams.**

- 10.14.1 Some States / Organisations have stated strengthening / setting up of hydrology units and review of hydrology of existing dams. The States of Gujarat, Madhya Pradesh, Maharashtra and Orissa have already taken up review of hydrology and completed for 152, 22, 28 & 18 dams respectively. The States of Andhra

Pradesh, Karnataka, Uttar Pradesh and West Bengal informed that hydrology units in their States are being set up shortly. Bihar, Rajasthan and Tamil Nadu also intimated about the progress in their States but there is no response so far from Kerala.

- 10.14.2 Chairman, NCDS suggested that, if possible, service of the existing hydrology units in the States may be utilized for the job. He also suggested examining the possibility of doing the job through consultants, namely, NIH, IIT and WAPCOS. All the States who have not started the hydrology review are requested to take appropriate action giving priority to dams of National Importance in their respective States to carry out such review.

(Action : All the States / Organisations)

#### **10.15 Data on gated storages.**

- 10.15.1 The States were requested to send data on gated storages for large dams in a specified proforma. Information has been received from the Andhra Pradesh, BBMB, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Tamil Nadu, Uttar Pradesh and West Bengal.
- 10.15.2 The State of Orissa has submitted data for 16 dams out of 48 and Rajasthan has given data for 8 dams out of 25. So far, no response is received from the State of Bihar.
- 10.15.3 As the information on gated storages is proposed to be included in the publication on dam safety, the above States are requested to supply the pending information at the earliest.

(Action : Bihar, Orissa & Rajasthan)

#### **10.16 Preparation of completion report of large dams**

- 10.16.1 During the ninth meeting of NCDS, it was opined by members that priority should be given to dams of National Importance while preparing the completion report of dams in their respective States.
- 10.16.2 As a part of completion report, BBMB has sent construction features of Beas Sutlej Link and Dehar Power Plan Vol.I & II. Tamil Nadu has sent history of Cauvery Mettur Project as completion report of Mettur dam. Maharashtra had completed the report on 10 dams and submitted completion report of

Gangapur dam. Karnataka has completed the preparation of the report for 13 dams, including three National Importance dams. Work is under progress in the case of Orissa, Gujarat and West Bengal.

- 10.16.3 In the meeting it was pointed out that the original geological reports would form part of the completion reports. All the States are requested to prepare completion reports giving priority to dams of National Importance and send one sample copy to DSO / CWC.

(Action : All the States / Organisations)

### **10.17 Preparation of Operation & Maintenance Manual.**

- 10.17.1 The States of BBMB, Gujarat, Maharashtra, Uttar Pradesh & West Bengal had already taken action to prepare Operation & Maintenance Manual. One copy each of Operation & Maintenance Manual has been received from the States of Gujarat for Karjan and Damanganga project. Maharashtra for Paithan dam (Jayakwadi), Uttar Pradesh for Yamuna H.E. Project, West Bengal for Kangsabati Reservoir and BBMB for Pandoh, Dehar, Beas and Pong dams. These manuals have not been received from the States of Andhra Pradesh and Madhya Pradesh.

- 10.17.2 The States of Andhra Pradesh, Bihar, Karnataka, Kerala, Orissa, Rajasthan & Tamil Nadu may complete this manual and send one copy to DSO / CWC.

(Action : All the States / Organisations)

### **10.18 Instrumentation for dams.**

- 10.18.1 During the sixth meeting of NCDS, it was decided to take stock of the status of instrumentation installed in large dams in order to see their performance, mortality, periodicity for analysis of data, referring the analysis to designers for their suggestions, status of structural behaviour report and the adequacy or otherwise of the staff engaged on this job.

- 10.18.2 So far, response has been received from the States of Madhya Pradesh for 11 dams, Maharashtra for 46 dams, Tamil Nadu for 6, Gujarat for 25 and BBMB for 3 dams. No information has been received from the States of Andhra Pradesh and Karnataka in compliance to the minutes of the ninth meeting.

- 10.18.3 During the meeting, the Chairman, NCDS suggested installation of micro-earthquake instruments in the existing dams. Chairman also informed that for the research work, funding can be arranged through Ministry of Water Resources if the research stations and type of instruments are identified by the States and reported to DSO / CWC.
- 10.18.4 The States, which have not reported on instrumentation, are requested to expedite the same without further delay.

(Acton : All States / Organisations)

### **10.19 Seismic status of dams of National Importance.**

- 10.19.1 In order to inspect dams after the occurrence of earthquakes, to assess damage to the dam and appurtenances, CWC had circulated to all members of NCDS a document titled "Guidelines for inspection of dams following earthquake." The States were requested to make use of this document and report to NCDS, after filling up the proforma embodied in the above document, immediately after the occurrence of an earthquake. It was expected that the States in north India would conduct a thorough inspection of their large dams after the Uttarkashi earthquake of October 1991 and report to NCDS of their findings.
- 10.19.2 Information have been received from BBMB for all three dams under their charge, from NHPC for Salal dam and from Uttar Pradesh for Ramganga dam. No damages have been reported in any of the above structures.
- 10.19.3 Members / States are requested to utilize the above referred document in future for inspection of dams under their charge following the occurrence of an earthquake of engineering significance in their States or nearby.
- 10.19.4 Chairman, NCDS observed that the Geological Survey of India had conducted detailed studies on seismicity of dam sites and the adjoining reservoir and is probably in a position to recommend measurements (gadgets) for monitoring micro seismic activity in and around the reservoir and also the instrumentation systems required for monitoring the structural response of the dam. He desired that Director, Dam Safety, CWC should write to GSI and obtain information on these issues.

(Action : All the States / Organisations & DSO / CWC)

**10.20      Standardized meteorological and other observations.**

- 10.20.1      In order to collect information on the type of meteorological observations installed by the States in the catchment areas and also in the reservoirs for large dams, the States were requested to supply detailed information in a form supplied to them by NCDS. The States had been sending information from time to time regarding meteorological observations and instruments installed at each dam site in their respective States. So far, the States of Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra and Orissa had responded and supplied information in respect of some dams in their States. BBMB had also given information in this regard. The State of Tamil Nadu intimated that it would install a weather station at each dam site.
- 10.20.2      The States of Bihar, Kerala, Rajasthan, Uttar Pradesh and West Bengal are requested to indicate the type of hydrometeorological observations conducted at individual dams in their States.

(Action : All the States / Organisations)

**10.21      Problem bank on research & development.**

- 10.21.1      The necessity of having a well defined problem bank on research and development related to issues concerning dam safety was discussed in the ninth meeting of NCDS wherein Chairman, NCDS desired that members shall suggest areas requiring research for development of processes and gadgets in the field of dam safety and send their suggestions to DSO of CWC.
- 10.21.2      In the absence of response from members of NCDS, so far DSO of CWC has made an attempt to categorise certain specific areas for research on dam safety as shown in Annex 2. Chairman, NCDS desired that the State should examine the list and take up research on a subject of their choice. They should prepare a project report on the scheme for research and send the same to Member (D&R), CWC for further processing. The subjects chosen for research need not necessarily pertain to the items in the list, as suggestions for additions to the list and modifications are also welcome.

(Action : All the States / Organisations)

## **List of special areas suggested for conducting research on dam safety**

The list of specific areas for conducting research on dam safety, category-wise suggested are as under:

### **1. Dam Foundation**

- (a) Improvements in tracer techniques for the detection of seepage sources and seepage paths and also further development in the technology of borehole TV and geologgers.
- (b) Define and develop techniques for evaluating permeability and to improve the existing system for conducting water pressure tests.
- (c) Research for further development of new techniques for impermeabilization criteria such as the free oscillation, air permeability and radioactive methods.
- (d) Research for defining the rock-type specific groutability and to develop the relationship between the penetration radius, grouting pressure, thickness of joints and viscosity of mix.

### **2. Fill Dams**

- (a) Studies to be conducted for understanding the causes of cracking and defining appropriate measures to remove or reduce the causes.
- (b) Research for defining a core material which would be less prone to cracking and more resistant to corrosion.
- (c) Research for defining criteria for the design of filters which could prevent migration of core particles once erosion has started.

### **3. Concrete & Masonry Dams**

- (a) Analysis and design : Defining and reviewing parameters like factors of safety, allowable stresses for analysis, reviewing models for dynamic analysis, etc.

- (b) Construction practices : Improvement of existing practices and the development of new techniques for the economical heightening of concrete / masonry dams and assessment of the performance of dams constructed, using new techniques like RCC and new composites.
- (c) Inspection & monitoring : Improving underwater inspection techniques and to evolve a quantified rating system for preliminary inspections.
- (d) Repair & maintenance : More experience with evaluation of commercial polymer systems and the development of a rating system for their performance and the development of better abrasion resistant composite materials.

### **3. Earthquake Consideration**

Areas for further research have been identified as under:

- (a) The influence of construction joints**
- (b) The concrete rock contact**
- (c) Pressurized cracks**
- (d) Fracture mechanics for triaxial structures and loads**
- (e) Fracture mechanics for dynamic loads (speed, fatigue)**
- (f) Numerical analysis**

### **4. Instrumentation**

- (a) Development of procedures and equipment to embed instruments in the dam body and foundation of existing dams.**
- (b) Development of transducers & readouts to facilitate measurement of several critical parameters simultaneously by specific sets of instruments (eg. Inclination & settlement).**
- (c) Improvement in transducer technology for ease in conversion of the signal to the parameter being monitored.**