



GOVERNMENT OF INDIA

**AERB SAFETY MANUAL**

**REGULATORY INSPECTION DURING CONSTRUCTION  
OF  
CIVIL ENGINEERING STRUCTURES  
IMPORTANT TO SAFETY OF NUCLEAR FACILITIES**



**ATOMIC ENERGY REGULATORY BOARD**

**AERB SAFETY MANUAL NO. AERB/NF/SM/CSE-4**

**REGULATORY INSPECTION DURING CONSTRUCTION  
OF  
CIVIL ENGINEERING STRUCTURES  
IMPORTANT TO SAFETY OF NUCLEAR FACILITIES**

**Atomic Energy Regulatory Board  
Mumbai 400 094  
India**

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**The Administrative Officer  
Atomic Energy Regulatory Board  
Niyamak Bhavan  
Anushaktinagar  
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India**

## FOREWORD

Activities concerning establishment and utilisation of nuclear facilities and use of radioactive sources are to be carried out in India in accordance with the provisions of the Atomic Energy Act, 1962. In pursuance of the objective of ensuring safety of members of the public and occupational workers, as well as protection of environment, the Atomic Energy Regulatory Board (AERB) has been entrusted with the responsibility of laying down safety standards and enforcing rules and regulations for such activities. The Board, has therefore, undertaken a programme of developing safety standards, safety codes, and related guides and manuals for the purpose. While some of these documents cover aspects such as siting, design, construction, operation, quality assurance and decommissioning of nuclear and radiation facilities, other documents cover regulatory aspects of these facilities.

Safety codes and safety standards are formulated on the basis of nationally and internationally accepted safety criteria for design, construction and operation of specific equipment, structures, systems and components of nuclear and radiation facilities. Safety codes establish the objectives and set requirements that shall be fulfilled to provide adequate assurance for safety. Safety guides and guidelines elaborate various requirements and furnish acceptable approaches for their implementation. Safety manuals deal with specific topics and contain detailed scientific and technical information on the subject. These documents are prepared by experts in the relevant fields and are extensively reviewed by advisory committees of the Board before they are published. The documents are revised when necessary, in the light of experience and feedback from users as well as new developments in the field.

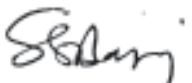
Civil engineering structures in nuclear installations form an important feature having implications on safe performance of these installations. This safety manual is written to specify the objective and details of the inspection during construction of civil engineering buildings/structures to provide adequate assurance for safety.

Consistent with the accepted practice, 'shall' and 'should' are used in the manual to distinguish between a firm requirement and a desirable option respectively. Annexures and bibliography are included to provide further information on the subject that might be helpful to the user. Approaches for implementation, different to those set out in the manual may be acceptable, if they provide comparable assurance against undue risk to the health and safety of the occupational workers and the general public, and protection of the environment.

For aspects not covered in this manual, applicable national and international standards, codes and guides acceptable to AERB should be followed. Non-radiological aspects, such as industrial safety and environmental protection, are not explicitly considered. Industrial safety is to be ensured through compliance with the applicable provisions of the Factories Act, 1948 and the Atomic Energy (Factories) Rules, 1996.

Specialists in the field drawn from the Atomic Energy Regulatory Board, the Bhabha Atomic Research Centre, the Nuclear Power Corporation of India Limited and other consultants have prepared this manual. It has been reviewed by experts and relevant AERB advisory committee on codes and guides and the advisory committee on nuclear safety.

AERB wishes to thank all individuals and organisations who have prepared and reviewed the document and helped in its finalisation. The list of persons, who have participated in this task, along with their affiliations, is included for information.

  
(S. S. Bajaj)  
Chairman, AERB

## DEFINITIONS

### **Admixture**

Material other than water, aggregate or cement, used as an ingredient of concrete and added to concrete before, during or subsequent to its mixing to modify its properties.

### **Anchorage (Pre-stressing)**

A device by which force is transferred to concrete. In post-tensioning, the device used is to anchor tendon to the concrete member, whereas in pre-tensioning, the device is used to anchor tendon during the hardening of concrete.

### **Anchor Head**

A nut, washer, plate, stud or bolt head or other steel components used to transmit anchor loads to the concrete by bearing.

### **Atomic Energy Regulatory Board (AERB)**

A national authority designated by the Government of India having the legal authority for issuing regulatory consent for various activities related to the nuclear and radiation facility and to perform safety and regulatory functions, including their enforcement for the protection of site personnel, the public and the environment against undue radiation hazards.

### **Audit**

A documented activity performed to determine by investigation, examination and evaluation of objective evidence, the adequacy of, and adherence to applicable codes, standards, specifications, established procedures, instructions, administrative or operational programmes and other applicable documents, and the effectiveness of their implementation.

### **Construction**

The process of manufacturing, testing and assembling the components of a nuclear or radiation facility, the erection of civil works and structures, the installation of components and equipment and the performance of associated tests.

### **Documentation**

Recorded or pictorial information describing, defining, specifying, reporting or certifying activities, requirements, procedures or results.

### **Embedment**

The embedment is that portion of the component which is in contact with the concrete or grout used to transmit applied loads to the concrete structure through direct bond or other anchor. The embedment may be fabricated lugs, bolts, plates, reinforcing bars, shear connectors, expansion anchors, inserts or any combination thereof.

### **Embedded Parts**

Any structural member, plate, angle, channel, pipe sleeve or other section anchored to a concrete structure through direct bond or other anchors.

### **Examination**

An element of inspection consisting of investigation of materials, components, supplies or services to determine conformance with those specified requirements which can be determined by such investigation.

**Inspection**

Quality control actions which by means of examination, observation or measurement determine the conformance of materials, parts, components, systems structures, as well as processes and procedures, with predetermined quality requirements.

**Inspector (Regulatory)**

A person authorised by the Regulatory Body to carry out regulatory inspection.

**Items Important to Safety (IIS)**

The items which comprise:

- (i) those structures, systems, equipment and components whose malfunction or failure could lead to undue radiological consequences at plant site or off-site;
- (ii) those structures, systems, equipment and components which prevent anticipated operational occurrences from leading to accident conditions;
- (iii) those features which are provided to mitigate the consequences of malfunction or failure of structures, systems, equipment or components.

**Nuclear Facility**

All nuclear fuel cycle and associated installations encompassing the activities from the front end to the back end of nuclear fuel cycle processes and also the associated industrial facilities such as heavy water plants, beryllium extraction plants, zirconium plants, etc.

**Nuclear Power Plant**

A nuclear reactor or a group of reactors together with all the associated structures, systems, equipment and components necessary for safe generation of electricity.

**Pre-service Inspection (PSI)**

The inspection performed prior to or during commissioning of the plant to provide data on initial conditions supplementing manufacturing and construction data as a basis for comparison with subsequent examinations during service.

**Primary Containment**

The principal structure of a reactor unit that acts as a pressure retaining barrier, after the fuel cladding and reactor coolant pressure boundary, for controlling the release of radioactive material into the environment. It includes containment structure, its access openings, penetrations and other associated components used to effect isolation of the containment atmosphere.

**Quality**

The totality of features and characteristics of an item or service that have the ability to satisfy stated or implied needs.

**Quality Assurance (QA)**

Planned and systematic actions necessary to provide the confidence that an item or service will satisfy given requirements for quality.

**Quality Control (QC)**

Quality assurance actions, which provide means to control and measure the characteristics of an item, process or facility in accordance with the established requirements.

**Records**

Documents, which furnish objective evidence of the quality of items and activities affecting quality. They include logging of events and other measurements.

**Regulatory Inspection**

An examination through review of documents, observation, measurement or test undertaken by or on behalf of the regulatory body during any stage of the regulatory consenting process, to ensure conformance of materials, components, systems and structures as well as operational and maintenance activities, processes, procedures, practices and personnel competence with predetermined requirements.

**Responsible Organisation**

The organisation having overall responsibility for siting, design, construction, commissioning, operation and decommissioning of a facility.

**Review**

Documented, comprehensive and systematic evaluation of the fulfillment of requirements, identification of issues, if any.

**Safety Analysis Report (SAR)**

A document, provided by the applicant/consentee to the regulatory body, containing information concerning the nuclear or radiation facility, its design, accident analysis and provisions to minimise the risk to the public, the site personnel and the environment.

**Secondary Containment**

The structure surrounding the primary containment that acts as a further barrier to limit the release of radioactive materials and also protects the primary containment from external effects. It includes secondary containment structure and its access openings, penetrations and those systems or portions thereof which are connected to the containment structure.

**Site**

The area containing the facility defined by a boundary and under effective control of facility management.

**Specification**

A written statement of requirements to be satisfied by a product, a service, a material or process, indicating the procedure by means of which it may be determined whether specified requirements are satisfied.

**Structure**

The assembly of elements which supports/houses the plants, equipment and systems.

**Surveillance**

All planned activities viz. monitoring, verifying, checking including in-service inspection, functional testing, calibration and performance testing carried out to ensure compliance with specifications established in a facility.

**Testing (QA)**

The determination or verification of the capability of an item to meet specified requirements by subjecting the item to a set of physical, chemical, environmental or operational conditions.

**Verification**

The act of reviewing, inspecting, testing, checking, auditing, or otherwise determining and documenting whether items, processes, services or documents conform to specified requirements.

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# 1. INTRODUCTION

## 1.1 General

Design and construction of buildings and structures, important to safety of nuclear facilities, are carried out as per considerations in design basis reports (DBR), and specifications and construction methodology conforming to regulatory requirements brought out in AERB safety codes and standards. The construction of civil engineering buildings and structures should be in conformance with Section 4 of AERB safety standard titled 'Civil Engineering Structures Important to Safety of Nuclear Facilities' (AERB/SS/CSE). Quality assurance programme adopted in construction to ensure desired quality contains details of organisational structure, quality plans, procedures for quality control and testing, and acceptance norms/standards. It is important that inspections are carried out during the construction stages to monitor fulfillment of the design intent. The disposal and enforcement actions of the inspection findings should be in accordance with Section 4 of AERB safety guide titled 'Regulatory Inspection and Enforcement in Nuclear and Radiation Facilities' (AERB/SG/G-4).

This safety manual describes various aspects related to inspection by regulatory body during construction of civil engineering buildings and structures important to safety. Important regulatory documents in this connection are 'Regulatory Inspection and Enforcement in Nuclear Power Plants and Research Reactors' (AERB/NPP&RR/SM/G-1) and 'Regulatory Inspection and Enforcement in Nuclear Fuel Cycle Facilities and Related Industrial Facilities other than Nuclear Power Plants and Research Reactors' (AERB/NF/SM/G-2).

It is recognised that proper procedures, facilities and organizational setup are created by responsible organisation (RO), to carry out various functions of quality assurance (QA) and quality control (QC) at the construction site. AERB assesses adequacy of the establishment at site to carry out the quality assurance functions, implementation of QA plans/procedures and documentary evidences for fulfillment of the approved QA programme as a part of its inspection programme.

## 1.2 Objective

The objective of this manual is to provide information for regulatory inspection (RI) to be carried out during the construction of civil engineering structures to verify the compliance of design intents, QA plan and the safety requirements by the RO, and for the appropriate enforcement actions that may follow the inspection.

## 1.3 Scope

Provisions of this manual are applicable to nuclear power plants, research reactors and nuclear fuel cycle facilities. The provisions can also be suitably applied for radiation facilities, and other related industrial facilities.

This manual is applicable for regulatory inspection during construction of civil engineering buildings, structures and components important to safety. However, this manual may provide useful information to conduct inspections for other agencies, for example, in-house inspections by the utility. Information provided in this manual may also be applicable to civil engineering buildings, structures and components in secondary areas.

The RIs are carried out to assess compliance of various procedures during pre-construction, construction and post construction stages in the areas of inspection outlined in the safety guide AERB/SG/G-4. This manual outlines suggestions related to establishment and implementation of inspection programme for civil engineering construction at site.

Important considerations in determining the extent of RI are :

- (i) the complexity, uniqueness or novelty of structure

- (ii) the degree of standardisation
- (iii) the need for special controls, administrative measures and surveillance over processes, methods and equipment
- (iv) the degree to which compliance with design requirements can be demonstrated by inspection and tests
- (v) the quality history of manufactured products
- (vi) the accessibility of the components after construction for maintenance and in-service inspection.

The findings of RI would help in assessing the potential of errors and omissions in the construction that might lead to non-compliance of design intent and quality assurance plan resulting in distress of the structure.

The regulatory aspects related to in-service inspection of civil engineering structures are not covered in this document. Reference may be made for the same to AERB safety manual titled 'In-Service Inspection of Civil Engineering Structures of Nuclear Power Plants (AERB/SM/CSE-2)'.

#### **1.4 Structure**

This safety manual comprises four sections including the first section on introduction and one annexure. Each section is divided into a number of subsections, which are further divided into a number of paragraphs.

- Section 1 - Introduction
- Section 2 - Organisation of regulatory inspection
- Section 3 - Programme of inspection
- Section 4 - Items of inspection
- Annexure -A - Typical list of civil engineering structures of pressurised heavy water reactor based nuclear power plants

## **2. ORGANISATION FOR REGULATORY INSPECTION**

### **2.1 Organisation**

The regulatory body will conduct RI and organise the inspection program as set out in this document.

The regulatory body should deploy adequately qualified personnel to conduct the inspection of items set out in this document either from its staff or other agencies/consultants.

The RO should ensure that all agencies involved in construction at site extend cooperation and provide assistance, documents and information that are necessary to carry out the inspection.

The inspection personnel should be provided prompt and unrestricted access to any area of the facility for the purpose of RI.

### **3. PROGRAMME OF INSPECTION**

#### **3.1 Stages of Inspection**

RI during the construction phase may be carried out in the following stages:

- (i) Before commencement of the construction
- (ii) During the construction
- (iii) After the completion of construction

#### **3.2 Places of Inspection**

Apart from the main construction site of the facility, the places of RI may include sources of ingredients, materials, manufacturing facilities and offsite construction yards. Where the services of contractors or vendors are used by RO, they should ensure that necessary arrangements are made for the RI at the respective work places.

#### **3.3 Frequency of Inspection**

Frequency of RI is decided depending on progress and complexity of construction, levels of radioactivity if any, exigencies that may arise at site, specific findings during safety review or on specific request by the RO. In general, the frequency of planned inspection should be in line with the requirements specified in AERB/NPP&RR/SM/G-1 and AERB/NF/SM/G-2. In addition to the number of planned inspections during construction, at least one inspection prior to start of construction and one after the completion of construction should also be carried out.

#### **3.4 Types of Inspection**

The regulatory inspections during construction of civil engineering structures are of two types :

- (i) Planned inspections or normal regulatory inspections
- (ii) Reactive inspections or special regulatory inspections

A planned inspection is conducted as per the schedule and plan drawn up by the regulatory body. Reactive inspections would be taken up in response to exigencies and emergencies that may arise at site or on specific request by the RO. Examples of reactive inspection are special inspections on construction deficiency, failure/accident during construction, abnormal occurrences noted during construction etc.

#### **3.5 Programme**

The manual provides information for RI with regard to the construction of civil engineering buildings and structures important to safety. The procedure for RI during civil engineering construction should be generally in line with the provisions of AERB/NPP&RR/SM/G-1 and AERB/NF/SM/G-2. This manual provides specific considerations for inspection of civil engineering construction activities. The civil engineering buildings, structures and components that are to be inspected vary from plant to plant. The inspection programme may also vary depending on the type of construction activities being performed at site. The RI programme should be worked out considering the particular plant and type of construction activity being undertaken at site.

#### **3.6 Documentation**

Findings of RI are brought out in the form of an inspection report. The reports are prepared in the standard formats provided in AERB safety manuals titled AERB/NPP/SM/G-1 for nuclear power plants and research reactors and AERB/NF/SM/G-2 for nuclear fuel cycle facilities.

### **3.7 Enforcement Actions**

Enforcement actions and disposal of inspection findings should be done in line with the guidance in AERB Safety Guide AERB/SG/G-4 titled 'Regulatory Inspection and Enforcement in Nuclear and Radiation Facilities'.

## 4. ITEMS OF INSPECTION

### 4.1 General

RI, with respect to civil engineering construction, covers the areas in line with the requirements laid down in AERB safety guide No. AERB/SG/G-4. Apart from the items included in subsequent sections of this manual, the RI also includes industrial safety and housekeeping. In specific cases, inspectors may ask for additional checks and safeguards for specific activity having implication on industrial safety.

AERB safety manuals AERB/NPP&RR/SM/G-1 and AERB/NF/SM/G-2 cover also the information on inspection related to industrial safety. Suggestions on inspection of instrumentation and mock ups are provided in subsections 4.5 and 4.6 of this manual respectively.

RI consists of verifying compliance with the regulatory requirements and continuous adherence to safety objectives of the nuclear facility under inspection. The inspection includes examination of the facility, the on-going activities, procedures, records, documents, surveillance and test procedures including results. The inspection also includes interviewing of personnel, and witnessing of tests and measurements.

Typical list of civil engineering structures, buildings and components of pressurized heavy water reactor based nuclear power plant to be inspected is given in Annexure-A.

Typical lists of items, which generally pertain to nuclear power plant construction, are given in this section depending on various stages and areas of construction. The list would help in preparation of regulatory inspection checklists. The inspection should include verification in implementation of QA plans and standards for each of these items.

Checking compliance of stipulations and recommendations of safety review committee should be part of inspection item.

Bought out items or shop fabricated items may be inspected at vendor's facility or its authorized agency's facility.

### 4.2 Inspection before Commencement of the Construction

Inspections should be performed in respect of the following items:

- (i) Construction authorization from AERB
- (ii) Approved plant layout drawings
- (iii) Approved construction schedule
- (iv) Site specific environmental data such as maximum flood level, temperature variation etc.
- (v) Geotechnical investigation report/records
- (vi) Report on study of safe blasting charges for rock excavation
- (vii) Approved drawings for initial construction work
- (viii) Topographical map including benchmarks in the project area connected with benchmarks of Survey of India
- (ix) Approved construction methodology document
- (x) Approved procedures for various activities
- (xi) Approved quality assurance manuals
- (xii) Availability of trained and qualified manpower
- (xiii) Availability of requisite equipment/machinery

- (xiv) Availability of adequate supervisory staff
- (xv) Safe storage of explosives, if any, required for rock excavation.

### **4.3 Inspection during Construction**

Items of inspection during and after excavation:

- (i) Detailed survey report indicating locations of survey pillars
- (ii) Excavation drawing including the slope profile, berm, protection arrangement for the stability of slope and dumping of excavated material at places not endangering the safety of slope
- (iii) Temporary surface drainage arrangement, and dewatering arrangements
- (iv) Procedure for excavation
- (v) Procedure for blasting and blasting data record
- (vi) Record of observations on peak particle velocities during blasting
- (vii) Founding strata after excavation and results of confirmatory tests on founding strata
- (viii) Record of clearances of founding strata by Designer
- (ix) Geological mapping and related report.

Items of inspection for consolidation grouting in foundation strata:

- (i) Approved ingredients and their proportion in grout mixes
- (ii) Procedure for consolidation grouting
- (iii) Record of water loss and grout intake
- (iv) Designer's approval of effectiveness of grouting of the foundation strata.

Items of inspection for construction of pile or well foundation in soil and soft rock:

- (i) Sub-soil test reports at foundation level
- (ii) Procedure for piling or well sinking
- (iii) Driving record of piles or well sinking
- (iv) Termination level of pile or well
- (v) Consumption of concrete in piles or wells
- (vi) Report on test piles or wells
- (vii) Routine tests results on piles or wells and soil strata
- (viii) Results of non destructive tests (NDT) on piles or wells
- (ix) Report on other types of foundations such as, caissons, diaphragm walls.

Items of inspection for rock anchors in foundations:

- (i) Approved drawings of anchor
- (ii) Qualification reports of the anchor components
- (iii) Procedure for installation of test anchors or rock anchors
- (iv) Record of grouting of rock anchors
- (v) Record of stressing of rock anchors
- (vi) Possible path of water ingress through or around anchors.

Inspection of storage and protection facilities of ingredient materials:

- (i) Cement storage facilities to verify weather resistance, types and ages of cement

- (ii) Aggregate stockpiles to verify physical separation of various aggregates, prevention of contamination, dust accumulation, temperature and moisture control
- (iii) Mineral and chemical admixture storage and handling/dispersing facilities to verify that deterioration and contamination are prevented.
- (iv) Water sources and cooling facilities to verify the specifications for water quality and concrete temperature are met
- (v) Storage of reinforcing (passive and prestressing) and structural steel
- (vi) Storage of embedded parts
- (vii) Storage of other important construction materials.

Inspection of reports for manufacturing and testing of concrete and other materials:

- (i) Reports on qualification and calibration of equipment for sampling and testing of ingredients of concrete, fresh and hardened concrete and other materials at site and in the site laboratory
- (ii) Reports on qualification of cement or cementitious materials, coarse and fine aggregates, water, ice, admixtures (both mineral and chemical), heavy density aggregate, fresh and hardened concrete, reinforcement, mechanical couplers, structural steel and other materials including routine as well as source qualification and test results
- (iii) Reports on approved proportion of various concrete and grout mixes
- (iv) Reports on qualification and calibration of equipment like batching plant, crushing plant, ice plant, transit mixers, concrete pumps etc.

Items of inspection for pre-placement, placement and post-placement of concrete:

- (i) In respect of foundation, preparation of founding strata and approval of various tests conducted on founding strata
- (ii) Production of concrete, transportation and arrangement for placement, compaction and curing
- (iii) Placement of concrete including EPs, instruments, formwork, reinforcement, pour card etc.
- (iv) Availability and deployment of adequate manpower
- (v) Availability of measuring/monitoring instruments and sampling facilities including manpower for these tasks, wherever required as per design/safety requirements
- (vi) Verification of provisions for structural monitoring, if any, as per designs/safety requirements
- (vii) Verification of post-concrete survey records and action taken reports following any defect/deficiency
- (viii) Procedure/records of any NDTs conducted and repairs carried out on defective element
- (ix) Qualification of vibrator operators.

Inspection of passive reinforcement:

- (i) Cutting and bending
- (ii) Lapping, splice (welding/mechanical)
- (iii) Bundling
- (iv) Cleaning.

Inspection of prestressing activities:

- (i) Verification of reports on qualification of prestressing accessories and prestressing steel/strands
- (ii) Verification of the availability of procedures for prestressing and grouting, schedule for prestressing and record of prestressing and grouting



- (iii) Approval by designers for the prestressing of the tendons to the design requirements prior to grouting
- (iv) Verification of provisions for structural monitoring, if any, as per design/safety requirements
- (v) Storage and preservation of accessories/equipment/material related to prestressing works
- (vi) In-situ protection prior to final sealing of the end anchorages.

Inspection of structural steel construction:

- (i) Qualification reports on materials such as tests on structural steel, bolts, washers, chemical analysis, physical defects, manufacturer's certificate etc.
- (ii) Fabrication shop inspection records, shipping release, protection during transportation, match marks
- (iii) Procedure for erection
- (iv) Reports on alignment and tightening of bolts, grouting of supports
- (v) NDT performed at site such as dye penetration test and magnetic particle test
- (vi) Temporary measures during construction such as bracing, temporary parts etc.
- (vii) Fabrication procedures, qualification of welders and welding procedures.

Items of inspection of embedded parts (EP):

- (i) Records pertaining to material inspection
- (ii) Fabrication procedure
- (iii) Workmen qualification
- (iv) Protection measures
- (v) Identification
- (vi) Storage and issue
- (vii) QA records pertaining to EP.

Items of inspection of caulking and painting:

- (i) Selection of paint and caulking compound
- (ii) Application procedure
- (iii) Post application tests such as thickness of paint film etc.
- (iv) Any ageing effect on the painted surface such as cracks.

Items of inspection of specific activities during construction:

- (i) Any work in progress and activities at work fronts
- (ii) Important mock-ups
- (iii) Occurrence of unusual events such as surface cracks, swelling, leaching, buckling, deformation, settlement, local failures etc.
- (iv) Any load test.

Items of inspection of other general items:

- (i) Design concession requests (DCR) and design change notices (DCN)
- (ii) Field changes
- (iii) Items of non-conformance and corrective measures.
- (iv) Those parallel construction activities, which are inconsistent from quality assurance considerations.

#### **4.4 Inspection after Completion of Construction**

RI of construction completion certificates for civil engineering buildings, structures and components should be carried out after completion of the buildings/structures and components. RO would prepare the certificates for buildings, structures and components as soon as the construction is completed as per the guidelines specified in AERB safety guide titled 'Quality Assurance during Site Construction of Nuclear Power Plants' (AERB/SG/QA-4).

Proof test or structural integrity test and integrated leakage rate test of containment structures should be witnessed by AERB inspectors. Approved procedures for such tests should be available at site. Report on such tests should be prepared by RO as per AERB safety guide on 'Proof and Integrated Leakage Rate Testing of Reactor Containments' (AERB/NPP/SG/O-15).

RI should be conducted on records of any other tests conducted on buildings/structures prior to handing over for regular use.

#### **4.5 Inspection of Instrumentation**

Instrumentation mainly consisting of load cells for monitoring stress in prestressing cables required for monitoring of structures should be inspected.

#### **4.6 Inspection of Mock-ups**

Mock ups required at various stages of construction should be identified at the design stage. The inspection of mock up should typically include approved procedure, implementation of procedure, and witnessing of the mock up and tests, if necessary.

## ANNEXURE-A

### TYPICAL LIST OF CIVIL ENGINEERING STRUCTURES OF PHWR BASED NUCLEAR POWER PLANTS

#### A.1 220 MWe and 540 MWe NPP

- (1) Reactor building (RB):
  - (a) Inner containment structure (ICS): It consists of inner containment wall (ICW), inner containment dome and base raft.
  - (b) Secondary containment structure (SCS): SCS contains secondary containment wall (SCW) and dome.
  - (c) Base raft (foundation)
  - (d) Internal structures (IS): Calandria vault, floors, walls and other vaults make the internal structures of RB.
- (2) Spent fuel storage bay (SFSB): Spent fuel storage bay consists of spent fuel building (SFB) and spent fuel pool (SFP).
- (3) Control building (CB)
- (4) Service building (SB)
- (5) Station auxiliary buildings (SAB)
- (6) Stack
- (7) Induced draught cooling towers (IDCT)
- (8) Diesel generator building (DGB)
- (9) Reactor auxiliary building (RAB)
- (10) Waste management (WMP) facilities
- (11) Safety related pump house (SRPH)
- (12) Fire water pump house (FWPH)
- (13) D<sub>2</sub>O upgrading structure: D<sub>2</sub>O upgrading building (UB) and D<sub>2</sub>O upgrading tower (UT) are part of this structure.
- (14) Tunnels and trenches
- (15) Turbine building (TB)
- (16) Cooling water pump house (CWPH)
- (17) Intake/outfall tunnels and structures
- (18) Outdoor switchyard (SY)
- (19) Transformer yard (TY).

#### A.2 700 MWe NPP

- (1) Nuclear building (NB) consisting of reactor building (RB) at centre encompassed by reactor auxiliary building (RAB), housing reactor auxiliary system, spent fuel system and part of facilities in service building, founded on a common raft
- (2) Control building (CB)
- (3) Station auxiliary buildings

- (4) Ventilation stack and stack monitoring room (SMR)
- (5) D<sub>2</sub>O upgrading plant, clean up and evaporation building
- (6) Waste management facilities and exhaust ventilation building
- (7) Induced draught cooling towers (IDCT)
- (8) Safety related pump house (SRPH)
- (9) Fire water pump house (FWPH)
- (10) Diesel oil storage area (DOSA)
- (11) Emergency makeup water pond (EMWP)
- (12) Tunnels and trenches
- (13) Turbine buildings (TB)
- (14) Natural draught cooling towers (NDCT)
- (15) Cooling water pump house (CWPH)
- (16) Demineralisation plant (DMP)
- (17) Chlorination plant (CHLP)
- (18) Fuelling machine and mechanical workshops
- (19) Intake/Outfall tunnels and structures
- (20) Outdoor switchyard (SY)
- (21) Transformer yard (TY)
- (22) Filtered water pump house
- (23) Plant water pump house (PWPH).

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## LIST OF PARTICIPANTS

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Dates of meeting : July 17, 2001  
September 25, 2001  
August 17, 2004

#### Members and Invitees of CCCSE:

Shri N.N. Kulkarni (Chairman) : NPCIL (Former)  
Prof. V.N. Gupchup : VJTI, Mumbai (Former Principal)  
Director (Civil Engineering) : Bureau of Indian Standards, New Delhi  
Prof. A. Dasgupta : DCL, Kolkata  
Shri R.B. Gunde : TCE, Mumbai  
Shri A.S. Warudkar : NPCIL (Former)  
Dr. P.C. Basu (Member-Secretary) : AERB  
Shri L.R. Bishnoi (Permanent Invitee) : AERB  
Shri V.S. Rajgopalan\* (Invitee) : AERB (Former)  
Smt P. Shylamoni (Invitee) : AERB

\* Author of the first draft of this manual

## LIST OF PARTICIPANTS

### ADVISORY COMMITTEE FOR REGULATORY DOCUMENTS ON CIVIL AND STRUCTURAL ENGINEERING (ACRDCSE)

Date of meeting : December 10, 2009

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Shri N.N. Kulkarni (Chairman) : NPCIL (Former)  
Shri A.S. Warudkar : NPCIL (Former)  
Dr. Prabir C. Basu : AERB  
Director (Civil Engineering) : Bureau of Indian Standards, New Delhi  
Shri R.P. Garg : NPCIL (Former)  
Dr. Amalendu Dasgupta : DCPL, Kolkata  
Shri S.M. Palekar : TCE, Mumbai  
Shri R.B. Gunde : TCE (Former), Mumbai  
Smt. Shylamoni P. (Member-Secretary) : AERB

## ADVISORY COMMITTEE ON NUCLEAR SAFETY (ACNS)

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