AERB SAFETY MANUAL NO. AERB/SM/CSE-1

MAINTENANCE OF CIVIL ENGINEERING STRUCTURES IMPORTANT TO SAFETY OF NUCLEAR POWER PLANTS

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FOREWORD

Safety of public, occupational workers and the protection of environment should be assured while activities for economic and social progress are pursued. These activities include the establishment and utilisation of nuclear facilities and use of radioactive sources and have to be carried out in accordance with relevant provisions in the Atomic Energy Act, 1962.

Assuring high safety standards has been of prime importance since inception of the nuclear power programme in the country. Recognising this aspect, the Government of India constituted the Atomic Energy Regulatory Board (AERB) in November 1983 vide statutory order No. 4772 notified in the Gazette of India dated 13.12.1983. The Board has been entrusted with the responsibility of laying down safety standards and framing rules and regulations in respect of regulatory and safety functions envisaged under the Atomic Energy Act of 1962. Under its programme of developing safety codes and guides, AERB has issued four codes of practice in the area of nuclear safety covering the following topics:

Safety in Nuclear Power Plant Siting

Safety in Nuclear Power Plant Design

Safety in Nuclear Power Plant Operation

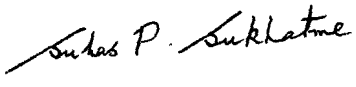
Quality Assurance for Safety in Nuclear Power Plants

Civil engineering structures in nuclear installations form an important feature having implications to safety performance of these installations. This safety manual is written to specify the objective and minimum requirements for the maintenance of civil engineering buildings/structures that are to be fulfilled to provide adequate assurance for safety of nuclear installations in India (such as pressurised heavy water reactor and related systems).

This manual may be revised as and when necessary in the light of experience as well as developments in the field. The appendix included in the document is an integral part of the document, whereas footnotes and references are to provide information that might be helpful to the user.

Emphasis in the codes, standards, guides and manuals is on protection of site personnel and public from undue radiological hazard. However, for aspects not covered in these documents, applicable and acceptable national and international codes and standards shall be followed. In particular, industrial safety shall be assured through good engineering practices and by complying with the Factories Act, 1948 as amended in 1987 and Atomic Energy (Factories) Rules, 1996.

This safety manual on civil and structural engineering (CSE) has been prepared by the staff of AERB, NPC, TCE and BIS. In its preparation, the relevant national and international documents (mentioned in the references section of this manual) have been extensively used. It has been reviewed by experts and amended by Advisory Committees before issue. AERB wishes to thank all individuals and organisations who have contributed in the preparation, review and amendment of the safety manual. The list of persons who have participated in committee meetings, along with their affiliation, is included for information.



(Suhas P. Sukhatme)
Chairman, AERB

DEFINITIONS

Atomic Energy Regulatory Board (AERB)

A national authority designated by the Government of India having the legal authority for issue of regulatory consent for various activities related to nuclear facility and to perform safety and regulatory functions including enforcement for protection of the public and operating personnel against radiation.

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 programme and other applicable documents, and the effectiveness of their implementation.

Decommissioning

The process by which a nuclear or radiation facility is finally taken out of operation, in a manner that provides adequate protection to the health and safety of workers, the public and of the environment.

Functional Testing

The test which ensures the design intent of structure/component.

Items Important to Safety

The items which comprise:

(a) those structures, systems, equipment and components whose malfunction or failure could lead to undue radiological consequences at the plant site or off-site;

(b) those structures, systems and components that prevent Anticipated Operational Occurrences from leading to Accident Conditions; and

(c) those features that are provided to mitigate consequences of malfunction or failure of structures, systems or components.

Nuclear Power Plant (NPP)

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

Performance Testing

Determination or verification of performance of an item to meet specified requirements by subjecting it to a set of operational conditions.

Quality Assurance

Planned and systematic actions necessary to provide adequate confidence that an item or a facility will perform satisfactorily in service as per design specifications.

Specifications

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

SPECIAL DEFINITIONS

(Specific for the Present Manual)

In-service Inspection

Inspections of structures, systems and components carried out at stipulated intervals during the service life of the plant.

Maintenance Programme

A systematic planning to keep the structure in serviceable condition and enable it to continue functioning as per design intent.

Operating Organisation

The organisation so designated by the responsible organisation and authorised by the Regulatory Body to operate the facility.

Predictive Maintenance

Programmed activities covering all predictive techniques like signature analysis, partial discharge tests etc. applicable to the equipment.

Preventive Measures

Process or actions meant to prevent occurrences that are detrimental to the structure.

Preventive Maintenance

Programmed/scheduled activities covering all preventive measures both administrative and technical, necessary to ensure that all structures, systems and components are capable of performing their intended functions for safe operation of the plant.

Qualified Person

A person, who having complied with specific requirement and met certain conditions, has been officially designated to discharge specific duties and responsibilities. [for example, Reactor Physicist, Station Chemist and Maintenance Person of Nuclear Power Plants are qualified persons]

Responsible Organisation (RO)

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

Routine Maintenance

Activity Programmed on routine basis functions to ensure that all structures, systems and components are capable of performing their intended functions for safe operation of the plant.

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.

CONTENTS

1. INTRODUCTION

1.1 General

1.1.1 Maintenance is considered to include functional and performance testing of civil engineering structures as well as their surveillance, in-service inspection and remedial measures where necessary either to support other maintenance activities or to ensure continuing capability of these structures to perform their intended safety functions. This applies no matter whether functional and performance testing, surveillance and in-service inspection are carried out by maintenance or other personnel. Guidelines for carrying out in-service inspection are covered in the AERB Safety Manual on In-service Inspection of Civil Engineering Structures Important to Safety of Nuclear Power Plants, AERB/SM/CSE-2.

1.1.2 Effective maintenance of civil engineering structures important to safety is essential for safe operation of a Nuclear Power Plant (NPP). This not only ensures that the level of reliability and effectiveness of all plant structures having a bearing on safety remain operational as per design intent and that the safety status of the plant is not adversely affected after commencement of operation.

1.1.3 This safety manual provides guidance on implementation of the provisions of "Safety Standard on Civil Engineering Structures Important to Safety of Nuclear Facilities" (AERB/SS/CSE) and "Code of Practice on Safety in Nuclear Power Plant Operation" (AERB/SC/O) on the maintenance of civil engineering structures.

1.1.4 The maintenance of civil engineering structures in NPP requires special attention because of the following:

(i) requirements that all safety-related civil engineering structures remain functional;

(ii) difficulties in accessing some plant building areas due to constraints in ensuring radiological protection;

(iii) requirements of prevention of radiological hazards to site personnel and the public;

(iv) requirement of maintaining structural integrity of containment and other structures important to safety with respect to ageing effects as well as due to consequences of any accident; and

(v) limitation on leakage through containment structures.

1.2 Scope

1.2.1 This manual covers organisational and procedural aspects of maintenance of civil engineering structures important to safety of NPP.

1.2.2 This manual provides guidelines on preventive and remedial measures necessary to ensure that all civil engineering structures important to safety are capable of performing as intended.

1.2.3 This manual also covers the organisational and administrative requirements for establishing and implementing preventive maintenance schedules, repairing defective locations of the plant civil

engineering structures, providing maintenance facilities and equipment, management of stores and spare parts, selecting and training of maintenance personnel, reviewing and controlling structural modifications arising from maintenance and for generating, collecting and retaining maintenance records for establishing and implementing an adequate maintenance information feedback system.

1.2.4 Maintenance work shall satisfy quality assurance requirements.

2. CIVIL ENGINEERING MAINTENANCE PROGRAMME

2.1 General

2.1.1 Before commencement of operation, the Operating Organisation shall prepare a maintenance programme for civil engineering structures important to safety. This programme should be made available to AERB.

2.1.2 The maintenance programme covers all preventive and remedial measures, both administrative and technical, necessary to perform maintenance activities satisfactorily. The range of activities include inspection (including in-service inspection), repair and replacement of parts, as appropriate and testing. It may also include modifications to structures.

2.1.3 Operating Organisation is responsible for establishing a programme for preventive and remedial maintenance to achieve continued performance as intended throughout the operational life of the plant.

2.1.4 Operating Organisation shall ensure that a maintenance group is established to perform all administrative, technical and supervisory functions. The group should also be responsible for mobilising and supervising on-site and off-site maintenance resources.

2.2 Establishing Civil Engineering Maintenance Programme

2.2.1 As early as possible during construction but not later than commissioning stage of the plant, a site maintenance group should be established to carry out maintenance of civil engineering structures. This group would take over responsibility of maintenance of the structures thereafter.

2.2.2 The maintenance programme of civil engineering structures of NPP shall be developed in accordance with requirements laid down in the AERB safety standard, "Civil Engineering Structures Important to Safety of Nuclear Facilities" (AERB/SS/CSE) and safety guide "Maintenance of Nuclear Power Plants" (AERB/SG/O-7).

2.2.3 An action plan for maintenance shall be written in line with the instructions of Responsible Organisation and the requirements set in this manual. The plan shall be approved by appropriate authority of the Operating Organisation. Action plan shall include the following:

(a) planning of methods of repair/maintenance, including tooling. In areas prone to high radiation field remote handling devices will preferably be used; and

(b) use of materials which are unstable in area subjected to radiation shall be avoided.

2.2.4 Operating Organisation should collect timely and sufficient information on maintenance needs from designers, construction organisation and other operating stations. It should also ensure that the programme is based on good maintenance practices.

Note: In the present context, the Nuclear Power Corporation of India Limited (NPCIL) is the Responsible Organisation for NPPs in India.

2.2.5 The maintenance programme shall cope with the following:

(a) plant structures that are in operation; and

(b) plant structures that are already constructed but awaiting operation.

The responsibilities of maintenance group of the Operating Organisation should be clearly defined and documented.

2.2.6 The maintenance programme of NPP shall be planned on the basis of periodic inspection. Inspection should typically include detection of physical damages, spalling, cracking, damage due to corrosion phenomena, loosening of EPs, joints of structural framework, leak detection of fluids, etc.

2.2.7 Special attention shall be paid to methods of maintenance while dealing with penetrations in containments, biological shields and restoration of surfaces, which have undergone vigorous decontamination process.

2.3 Design Liaison

2.3.1 Close liaison between Operating Organisation and design group of Responsible Organisation should be maintained throughout the life of NPP. It is particularly necessary to ensure effective and timely assistance from design group when plant faults occur or when modifications are required. For this purpose, Operating Organisation should arrange feedback of operating experience and performance data to the design group.

2.3.2 The close liaison between Operating Organisation and design group of Responsible Organisation is essential to ensure that the final maintenance programme is based on a clear understanding of the design philosophy and plant details, that the plant is designed to facilitate and minimise maintenance, and that any exposure to personnel is kept as low as reasonably achievable (ALARA).

2.3.3 Operating Organisation should arrange for study of design and construction aspects of civil engineering structures by its staff experienced in maintenance. This helps in monitoring operational parametric data. This also enables in establishing a systematic and effective maintenance programme with minimal radiological exposure. The study should cover the following:

(a) access to plant location;

(b) adequacy of handling devices;

(c) available space for removal and replacement of components;

(d) area available for in-situ work;

(e) interference with operation and maintenance of other structures;

(f) provision for shielding and access control, both permanent and temporary;

(g) adequacy of maintenance and storage facilities;

(h) adequacy of ventilation in areas that may be used for temporary maintenance work;

(i) adequate provision for effective isolation of electrical and mechanical devices;

(j) draining and venting facilities on systems and equipment;

(k) adequacy of stocks of spare parts;

(l) provision for handling and storing either temporarily or permanently activated or contaminated items, tools, etc. particularly in the controlled areas;

(m) ease of maintenance, inspection and decontamination of components during and after maintenance;

(n) adequacy of documentation;

(o) experience of other operating stations in maintenance of civil engineering structures; and

(p) provision for in-situ inspection, periodic data collection and monitoring the same. (This may be useful in assessing the damage and/or damage potential to civil engineering structures important to safety).

2.3.4 Certain construction phases provide experience and information for future operational activities, including maintenance and surveillance. Therefore the Operating Organisation may arrange for involvement, particularly of its maintenance personnel, in construction activities so that they undergo hands-on training in complex operations requiring special skills. This participation may not only help in detecting any discrepancies between approved specifications, methods and techniques actually used during construction before they can endanger safety, but it should also assist in the development of operating and maintenance instructions and in the transfer of all requisite "as-built" documentation.

2.4 Data Monitoring and Periodical Review

The maintenance group shall periodically monitor data as well as review maintenance records for evidence of incipient or recurring failures. When remedial maintenance is desirable either during this review or during preventive maintenance of the plant, the maintenance group shall initiate remedial maintenance in accordance with administrative procedures. The preventive maintenance programme shall be revised accordingly. The group should also review the data obtained from long-term monitoring equipment, especially the following:

(i) as part of the maintenance procedure, external loads or their effects such as intensity of earthquake at site, intensity of wind velocity at site, temperature variation etc. should be monitored and compared with those used in design;

(ii) records of measurements from instrumentation erected in various structures should be checked periodically; and

(iii) other important records of measurement such as vibration should be compared with original vibration periodically.

Any unusual or unexpected data observed from instruments should be collated by the Operating Organisation and reported to appropriate groups/section of the Responsible Organisation for necessary action.

2.5 Maintenance Manual

2.5.1 Operating Organisation should prepare a maintenance manual for civil engineering structures which should cover all relevant items in line with provisions of this document. The manual should cover both preventive and remedial maintenance.

2.6 Preventive Maintenance

2.6.1 Preventive maintenance entails pre-planned routine inspection, repairing and testing of civil engineering structures. Its purpose is to detect incipient failures and to ensure continuing capability of the structure to perform its intended functions. These pre-planned activities shall be specified in a preventive maintenance schedule. Typical maintenance schedules of civil engineering structures is given in the Appendix.

2.6.2 Copies of all safety analysis reports, design basis reports, design reports, specifications and drawings duly updated, as "as-built" shall be available with the Operating Organisation.

2.6.3 Operating Organisation shall review, as appropriate, lists of civil engineering structures to ensure that all structures important to safety have been identified for maintenance. Safety analysis report, design basis report, design description documents and specifications, are used for such identification of civil engineering structures.

2.6.4 The frequency and extent of preventive maintenance of structures included in preventive maintenance schedule shall be established after taking into consideration:

(i) design requirements;

(ii) designer's/supplier’s recommendations;

(iii) the relevant experience of Operating Organisation and good maintenance practices; and

(iv) environmental conditions.

2.6.5 The frequency and extent of preventive maintenance may be effected by utilisation of predictive maintenance methods. These methods are based on surveillance of carefully selected parameters and a special analysis of results. This analysis may be used to justify postponement of remedial actions or anticipation of scheduled maintenance. Such decisions shall only be taken at a suitable, designated level of authority in accordance with an arrangement, which has been subjected to independent review and approval, by the regulatory authorities. Any decision to postpone or anticipate scheduled maintenance shall only be taken after ascertaining that violations of operational limits and conditions or other effects detrimental to safety are prevented.

2.7 Remedial Maintenance

2.7.1 The need for remedial maintenance may arise when deficiencies or failures are noticed during plant operation. In such cases, Operating Organisation shall draw up appropriate procedures, e.g. work order, authorisation and area/equipment isolation, work permit, including reporting such failures to maintenance group and to recommend identifying the deficient items for withdrawal from service for remedial maintenance. The procedures should require operating personnel to assign priority to remedial work based on its importance to safety and taking into account prescribed operational limits and conditions. In doing so no compromise should be made on safety functions.

2.7.2 Detailed planning for condition monitoring of civil engineering structures is to be done by maintenance group in accordance with the monitoring work to be carried out. For this, deployment of engineers from other stations could be considered. This would result in a more independent and objective assessment.

2.7.3 After completion of any remedial maintenance a brief report of repairs or replacements carried out should be prepared, identifying the item that failed, its mode of failure, the remedial action taken, the total repair time, and the state of the item after remedial maintenance work.

2.7.4 Defective structural items shall be repaired in accordance with approved procedures.

2.7.5 If repairs are done in-situ, post-maintenance tests if necessary, and procedures for returning to service shall be as described in sub-section 2.7.7 below.

2.7.6 When remedial maintenance can be most conveniently accomplished by removing the defective structural item and building or erecting new one, it shall be done in accordance with approved procedures.

2.7.7 When a defective structural item has been replaced, suitable functional or performance tests, wherever necessary, shall be carried out as per approved test procedure jointly with operating personnel. Test results should satisfy acceptance criteria and shall be documented.

2.7.8 When plant repairs consist of more than merely replacing structural parts by an identical one, a review shall be made as to whether the repair will involve changes sufficient to require application of the plant modification control procedure described in section 6.

2.7.9 Wherever possible, upgradation of safety function, in line with current safety requirements, should be considered for existing structures important to safety.

2.8 Civil Engineering Maintenance Planning

2.8.1 Maintenance activity has to be planned in the context of planning of the Operating Organisation because of the complexity of a NPP as the activities of different units with plant management interface with one another in ways that are significant for safety. Civil maintenance group will carry out its own work scheduling within the overall plan.

2.8.2 Advantage should be taken of any shutdown to undertake maintenance. Appropriate maintenance schedules should be readily available in the event of unplanned as well as planned shutdowns.

2.8.3 Control room personnel shall be informed (e.g. by a work permit procedure) of all maintenance work before commencement, any changes to the plant that it entails, and when the plant has been returned to the responsibility of the Operating Organisation. Adequate communication shall be maintained between maintenance and control room operating personnel during performance of the work.

2.9 Master Layout for Services

The Operating Organisation should prepare a master layout for all services for the plant within the safety structure as well as outside the plant. This layout should be easily and readily accessible for reference. The operating station may continue to follow the practice of updating the master service layout from time to time following any addition or alteration as approved by the appropriate authority.

3. ORGANISATION AND RESPONSIBILITIES OF CIVIL ENGINEERING MAINTENANCE SECTION

3.1 Organisational Structure

3.1.1 Operating Organisation shall establish an adequate and suitable civil engineering maintenance section under the maintenance group of the station to implement the maintenance programme for civil engineering structures. Operating Organisation shall ensure the availability of sufficient number of adequately qualified personnel to implement the civil engineering maintenance programme as per AERB safety guide on "Staffing, Recruitment, Training, Qualification and Certification of Operating Personnel of NPPs" (AERB/SG/O-1). The civil engineering maintenance section shall typically consist of the following personnel:

(i) section head;

(ii) supervisors; and

(iii) technicians.

The section head should be a competent and qualified civil engineer. A typical organisational chart for civil engineering maintenance activities is given in Fig.1.

3.2 Responsibilities

3.2.1 Responsibilities of civil engineering maintenance section and supervisory staff should be defined by the Operating Organisation which should ensure that civil engineering maintenance section works in close coordination with such sections as operations, health physics, quality assurance, technical services, fire protection, industrial safety and stores etc.

3.2.2 The minimum responsibilities of various managerial and supervisory positions of civil engineering maintenance section should include:

(i) Section head (civil engineering maintenance):

Implementation of maintenance in accordance with quality assurance programme and instructions of the maintenance superintendent; specification and inventory control of spares; preparation of maintenance procedures and updating the same in the light of experience gained, e.g., radiation exposure, work methods; provision of adequate supervision of work, assistance in administration of maintenance personnel, planning and allocation of resources in accordance with the overall plan; reporting progress and results to the maintenance superintendent; review and approval of work measurements and records.

(ii) Supervisors (in the area of work assigned to them):

Allocation of resources to various jobs in the daily work plan; observation of progress and quality of work, assurance that procedures are followed; generation, collection and processing of records; recording of work measurements and report of work status and progress to the section head (civil).

(iii) Technicians :

Technicians shall do the allotted work as per instructions of supervisors.

3.2.3 The section head and supervisors shall ensure that maintenance personnel observe radiation protection measures, as stipulated by plant health physics unit, without any failure.

3.3 Selection and Training of Maintenance Personnel

3.3.1 Selection of maintenance personnel shall be in line with provisions of the AERB safety guide, "Staffing, Recruitment, Training, Qualifiation and Certification of Operating Personnel of NPPs (AERB/SG/O-1)" as given in 3.1.1. The provisions in the following sub-section also apply to outside personnel as appropriate to the type and duration of their job on site.

3.3.2 All maintenance personnel shall be given training in radiological protection, industrial safety, access control and emergency procedures appropriate to their duties, and they shall be adequately authorised in these aspects before being allowed to work in controlled areas. Training in radiological protection shall be as per guidelines given in AERB safety guide, "Radiation Protection during Operation of NPPs" (AERB/SG/O-5).

For special jobs, maintenance personnel should receive a special briefing appropriate to the job on safety of the plant, the related potential risks and the consequent safety precautions required. Maintenance personnel shall also be appropriately trained and qualified in quality assurance requirements applicable to their duties.

Rotation of personnel from one site to another is recommended to avoid job fatigue in cases where a person has been retained in one site for too long.

3.3.3 Maintenance technicians shall be trained and shall have to initially demonstrate a satisfactory level of skill. They shall also be trained to understand plant systems and equipment appropriate to their job. Each technician should be trained in several areas of the Operating Organisation to provide flexibility in job allocation. This will not only result in greater efficiency of manpower but will also enable minimising the radiation exposures of individuals.

4. ADMINISTRATIVE CONTROL

4.1 The entire civil group is administratively responsible to the maintenance superintendent of the plant and in this respect Section-4 of AERB safety guide "Maintenance of NPPs" (AERB/SG/O-7) will be applicable.

5. MAINTENANCE FACILITIES

5.1 General

5.1.1 Maintenance facilities are to be provided by Operating Organisation as per provisions contained in Section-5 of the AERB safety guide "Maintenance of NPPs" (AERB/SG/O-7).

5.1.2 In addition, the following facilities shall be made available at site:

(i) plumbing and sanitary appliances: Fixtures and fittings constantly required shall be maintained in the stores. Inventory shall be maintained with minimum stock of materials;

(ii) concreting: Concrete mixer, vibrators, pneumatic breakers, drills, jack hammers etc. shall be available at site in required numbers. Operators should be familiar with procedures of operation of these equipment;

adequate quantity of concrete ingredients including cement shall be maintained in stores and will be utilised as and when required. The quality of cement deteriorates with age. Therefore, before using stored cement, its age should be ascertained. If its strength is in doubt, the cement may be tested;

(iii) painting: Paints required functionally for repeated maintenance shall be in sufficient stock in the stores. Painting appliances such as airless spray gun, normal air pressure gun, brushes, personal safety appliances etc. shall also be in stock in adequate quantity;

(iv) essential carpentry tools required for carpentry work should be available;

(v) general tools and plants: Overall civil shop equipment, such as pans, wheel barrows, drilling machines, pneumatic equipment, equipment for breaking, excavation etc. shall be available in adequate numbers;

(vi) tools and plants required for remote operation may be drawn from other groups under the control of maintenance superintendent; and

(vii) non-destructive testing equipment: Schmidt hammer, ultrasonic pulse velocity testing equipment, crack detection microscope, paint thickness gauge, carbonation test facility, etc. should be available.

6. MODIFICATIONS ARISING FROM MAINTENANCE

6.1 Types of Modifications

Modifications may be necessary to rectify structural failures discovered during maintenance, to reduce frequency of failures, to improve maintainability or to improve operational performance. Modifications may include physical changes or changes in procedures.

6.1.1 Modifications to structures shall satisfy requirements detailed in Section: 16 of the "Code of Practice on Safety in NPP Operation" (AERB/SC/O), Safety Guide on "Commissioning Procedures for Pressurised Heavy Water Reactor Based NPPs" (AERB/SG/O-4) and "Management of NPPs for Safe Operation" (AERB/SG/O-9) may also be referred for further guidance.

6.2 Review Requirement

6.2.1 In accordance with quality assurance requirement, the Operating Organisation shall arrange for an independent review of proposed modifications to structures important to safety arising out of maintenance activities. Operating Organisation shall classify modifications as minor or major so that those judged to be major and important can be submitted to qualified persons for an independent assessment.

6.2.2 Notwithstanding these general criteria, the Operating Organisation should specify those plant structures and systems that are considered so significant to safety that no modifications to them can be judged as minor.

6.2.3 The above mentioned directives should allow for rapid review and assessment of any proposed modifications that have to be undertaken urgently, nevertheless such emergency action shall not reduce the level of safety. In these circumstances, retrospective formal documentation shall be completed without undue delay.

6.2.4 The plant modification control procedure issued by the Operating Organisation, should clearly allocate responsibility for coordinating modifications, implementing the on-site classifications, and review process, for liaison with an independent assessment process for administering controls relating to implementation and documentation of approved modifications and for disseminating information to specified bodies.

6.3 Submission of Proposals

6.3.1 Proposals for major modifications submitted by Operating Organisation for independent assessment shall include the following:

(i) design description and reason for modification;

(ii) safety analysis reports;

(iii) sketches, drawings and material list;

(iv) specifications for material and installation;

(v) applicable codes, standards and safety reports;

(vi) fabrication, installation and test method;

(vii) adverse environmental or operating condition; and

(viii) quality assurance requirements.

6.3.2 When so required, the proposed modification shall be submitted to the Regulatory Body for approval before implementation.

6.4 Implementation and Documentation

Operating Organisation shall prepare, record and report on modifications implemented and revise the drawings in permanent record.

7. STORES

7.1 General

7.1.1 The maintenance group of Operating Organisation shall be responsible for ensuring adequate stock of tools and resources to achieve its objective. It shall be responsible for establishing stock levels and authorising issue of stores.

7.1.2 Procurement, receipts, storage and issue of tools, equipment and materials for civil maintenance shall be as per approved procedures for plant store.

7.1.3 The above provisions are to be followed as per Section: 8 (Stores) of the AERB safety guide "Maintenance of NPPs" (AERB/SG/O-7).

8. RECORDS

8.1 General

8.1.1 Generation and collection of records, retention of records in respect of maintenance of civil engineering structures of the station should be as per provisions of guidelines in Section 9 of the AERB safety guide "Maintenance of Nuclear Power Plants" (AERB/SG/O-7).

8.1.2 Copies of record of all design documents, specifications, drawings, etc. duly updated as "as built" should be available with the Operating Organisation.

9. INSTRUMENTATION

9.1 General

9.1.1 To monitor the behaviour of safety-related civil engineering structures of NPPs, it is essential to observe the strains in structural elements, prestressing force in cables, settlement of structure, crack width, and creep of concrete during the life period. In order to collect data, necessary instrumentation is to be carried out during construction stage itself.

9.1.2 Appropriate procedure shall be finalised and included in the technical specification and maintenance manual of the station for protection, maintenance, storage, and data analysis.

9.2 Instrumentation for Long-Term Structural Monitoring of Primary Containment

9.2.1 Instrumentation provided for long-term structural monitoring of primary containment structures typically consist of the following:

(i) embedded type vibrating wire strain gauges (VWSG) embedded in the concrete at various locations to measure internal strains in the containment structure;

(ii) surface-mounted type vibrating wire strain gauges fixed on the surface of the containment to measure strains on the surface;

(iii) dynamometers provided at prestressing cable ends to measure prestressing force in selected cables;

(iv) creep rigs and hydraulic jack to monitor effect of creep on concrete specimen;

(v) N3 high precision level and plates fixed on concrete surface for monitoring of absolute and differential settlement of containment;

(vi) crack detection microscope for measuring crack widths on concrete surface; and

(vii) associated cables, read-outs and data loggers for the above instruments.

9.2.2 Frequency of Data Collection

After completion of prestressing of the containment, data collection for long-term structural monitoring of containment shall be carried out as per the following schedule:

(i) Strain measurement using embedded type VWSGs and surface-mounted VWSGs:

(a) after completion of full prestressing of containment structure;

(b) at one-year intervals during the entire life span of containment structure;

(c) whenever pressure tests (proof test and leakage rate tests) are conducted; and

(d) if any other abnormal condition occurs affecting integrity/performance of the containment structure.

(ii) Compressive strength, modulus of elasticity, poisson's ratio tests:

(a) three standard cylinders and cubes shall be tested at the age of 3 days, 7 days, 15 days, 28 days, 3 months, 6 months, 1 year, 5 years and then at an interval of 5 years for a total of 40 years. Total number of cubes and cylinders required = 45 cubes + 45 cylinders; and

(b) these samples shall be kept in concrete testing laboratory until construction is completed. The samples shall then be stored inside the reactor building at an elevation of 100 m floor (accessible area) and proper notice shall be displayed at that location for protection of the samples.

(iii) Creep studies

Data shall be collected at the same frequency as followed for strain measurement in containment structure as given above in section 9.2.2(i).

(iv) Shrinkage studies

For time period up to one year since casting of the sample, strains shall be measured at 3 days, 7 days, 15 days, 28 days, 3 months, 6 months, and 1 year of age.

For periods between sample ages of 12 months, 18 months and 24 months and subsequently every year for 5 years and whenever proof/leakage rate tests are conducted.

(v) Settlement measurement

Data will be collected using high precision N3 level:

(a) once a year during the entire life span of the plant;

(b) during in-service proof and leakage rate tests; and

(c) after any abnormal event affecting structural integrity of the containment.

9.3 Seismic Instrumentation

9.3.1 In regard to seismic instrumentation, reference should be made to AERB safety guide "Seismic Studies and Design Basis Ground Motion for Nuclear Power Plants Sites" (AERB/SG/S-11).

9.4 Other Instrumentation

9.4.1 For other instrumentation such as that for evaluating geotechnical aspects, reference should be made to AERB safety guide, "Geotechnical Aspects for Buildings and Structures Important to Safety of Nuclear Facilities" (AERB/SG/CSE-2).

9.4.2 Provision should be made for any special type of instrumentation or monitoring and measuring if specified from design considerations or regulatory stipulations.

9.5 Data Collection, Storage and Analysis

(i) After collection of data, the maintenance group of Operating Organisation shall send the data in approved format to the design group of Responsible Organisation for analysis, interpretation and comparison with previous data and predicted values. The design group shall submit a detailed report to the Regulatory Authority at 4-year interval or after integrated leakage rate test (ILRT) at design pressure or after any other abnormal event affecting structural integrity.

(ii) Read-outs, data loggers, hydraulic jacks etc. shall always be kept in operating condition. Adequate stock of necessary spares/consumables for proper data collection shall be maintained at station.

(iii) Operating Organisation shall identify the section responsible for data collection, maintenance of instruments, maintenance of records, and submission of data to design group for further processing. Design group of Responsible Organisation shall send sufficient copies of their report to the Operating Organisation, of which one copy shall be kept as permanent record by Operating Organisation.

9.6 Protection and Maintenance of Instrumentation

(i) Adequate protection of instrumentation should be ensured during construction and operation period of the plants. Instruments should be maintained as per manufacturers' specifications;

(ii) No concrete shall be removed or drilled from the strain gauge locations without prior approval of the design group; and

(iii) Surface-mounted strain gauges, embedded plates, cables etc. shall be protected from any kind of damage so that data collected is uninterrupted throughout the life of the plant.

10. QUALITY ASSURANCE FOR MAINTENANCE ACTIVITIES

10.1 General

10.1.1 The quality assurance programme will be written and implemented for in-service inspection, modifications and repair jobs. For all major modifications and repairs, documentation will be generated to ensure quality. Such a documentation shall be preserved. Quality assurance in general should cover the following:

(i) design procedure;

(ii) repair/modification procedure;

(iii) post-repair/modification inspection; and

(iv) materials used in repair/modification, non-destructive test (NDT) where required.

10.1.2 Provisions of Section-9 of AERB safety standard on "Civil Engineering Structures Important to Safety of Nuclear Facilities', AERB/SS/CSE and the AERB safety guide on "Quality Assurance during Commissioning and Operation of NPPs" (AERB/SG/QA-5) should be complied with for quality assurance of maintenance activities.

10.2 Surveillance, Review and Audit Programme

10.2.1 The need for surveillance and review of maintenance of civil engineering structures of the station should comply with provisions of Section-9 of the AERB safety standard on "Civil Engineering Structures Important to Safety of Nuclear Facilities" (AERB/SS/CSE).

10.2.2 Provisions of guidelines in Section-10 of AERB guide on "Maintenance of Nuclear Power Plants" (AERB/SG/O-7), should also be complied with for surveillance, review and audit programme.

APPENDIX

MAINTENANCE SCHEDULE FOR CIVIL ENGINEERING STRUCTURES

A.1 General

A.1.1 This Appendix provides guidelines on major aspects of maintenance of civil engineering structures of NPP. Detailed procedures of maintenance work should be developed based on guidelines and approval obtained from appropriate authority prior to commencement of maintenance work. Actual maintenance schedule will vary from station to station to suit local requirement. It specifically deals with maintenance of reactor building and generally covers maintenance aspects of civil engineering structures of the plant.

A.1.2 Whenever any unusual incident occurs and a sign of distress is identified, a detailed and specific maintenance programme should be taken up.

A.1.3 Remedial measures indicated in the Appendix are for some general cases. Operating Organisation should develop detailed remedial measures for all cases.

A.2 Maintenance Schedules

A.2.1 Civil engineering maintenance schedule for reactor building and all other plant structures and general housekeeping are shown in the Tables A.1, A.2 and A.3 respectively, in this Appendix.

TABLE:A.1: SCHEDULE FOR REACTOR BUILDING

Sl. No.	Structure/ Components	Items to be inspected and attended to	Frequency of inspection and maintenance
1	Foundation raft, stressing gallery	Ground water leakages, leaching marks, cracks, spalling of concrete, corrosion of reinforcement, deterioration of surface coating etc. Exposed portion of anchorages of unbonded cables are to be checked for rusting or leakage and anticorrosion agents, look for leakage of water from the suppression pool etc., and cleanliness	Once in six months
2	Suppression pool and structures within the pool including distribution headers	Deterioration of protective coating, ingress of water from ground, cracks, opening of construction joints, EPs, penetrations, cleanliness, etc.	At the earliest available opportunity or when need is evidenced subject to at least once between two consecutive full pressure in-service ILRT (pool has to be emptied for maintenance or an alternate method followed acceptable to AERB)
3	Containment Structure		
	(a) Inner surface of primary containment structure	(i) Cracks in concrete, peeling of paint, cracking of epoxy coating, separation of polysulphide caulking compound, man-made damage to paint and concrete, disintegration of dry pack mortar over prestressed cable anchorages, liners, EPs and penetrations and general cleaning, SG opening covers on dome etc.	Once in two years during annual shutdown
		(ii) Painting of inner surface and re-caulking of construction joints wherever to the extent found necessary	During full pressure in-service ILRT

TABLE:A.1: SCHEDULE FOR REACTOR BUILDING (contd.)

Sl. No.	Structure/ Components	Items to be inspected and attended to	Frequency of inspection and maintenance
	(b) External surface of primary containment structure and inner surface of secondary containment structure	(i) Cracks in concrete, peeling of paint, cracking of epoxy coating, separation of polysulphide caulking compound, man-made damage to paint and concrete, disintegration of dry pack mortar over prestressed cable anchorages, epoxy sand mix, liners, EPs and penetrations and general cleaning, SG opening covers on dome etc.	Once in two years during annual shutdown
		(ii) Painting of inner surface and re-caulking of construction joints, wherever to the extent found necessary	During full pressure in-service ILRT
	(c) External surface of outer containment structure and dome	(i) Cracks, spalling of concrete, corrosion of re-steel and embedded parts, access ladder, ageing of insulation and water-proofing of roof (dome china mosaic)	Once a year during annual shutdown
		(ii) Rainwater down-comers, gratings at inlet entry locations.	Before rainy season and during first heavy rain
4	Internal floors and walls, hatches, hatch covers and vent shaft of reactor building	(i) Cracking of concrete, deterioration of paint and caulking compound, man-made damages to paint and concrete by welding and cutting, floor drainage, EPs, penetrations, edge protection liners, fitting of hatch covers, general cleaning etc.	During annual shutdown
		(ii) Painting and caulking of joints as required.	As and when required
		(iii) Painting and caulking of floor joints wherever found necessary	During shutdown

TABLE:A.1: SCHEDULE FOR REACTOR BUILDING (contd.)

Sl. No.	Structure/ Components	Items to be inspected and attended to	Frequency of inspection and maintenance
5	FM vaults, FM servicing bays and SG vaults	Cracking and spalling of concrete, painting, caulking, liner, embedded part (EP) and penetration, floor drainages and external surface of calendria vault, pressure walls, cleanliness etc.	During shutdown as and when radiation level permits working
6	Annular space platforms, ladders, stairs and handrails	(i) Corrosion and rusting, loosened or missing bolts, weld cracks, painting, damages to platforms, ladders, handrails, stairs, doors etc. (ii) Repainting	During annual shutdown As and when required
7	Miscellaneous steel structures such as ladders, stairs, partition walls and handrails	(i) Corrosion and rusting, weld cracks, loosened or missing bolts, dislocation and general damage to structures, damages to paint coating etc. (ii) Repainting	During annual shut down As and when required
8	Main steel structures, columns, beams, bracings and bearings	(i) Corrosion, bolts, condition of bearings, welded joints (ii) Repainting (iii) Checking of beam pocket for accumulation of dust and dirt etc.	During full pressure in-service ILRT As and when required During full pressure in-service ILRT
9	Shielding blocks	General deterioration, physical damage, cracks in blocks, joints, missing block connections, etc.	During full pressure in-service ILRT

TABLE A.2: SCHEDULE FOR ALL OTHER PLANT STRUCTURES

Sl. No.	Structure/ Components	Items to be inspected and attended to	Frequency of inspection and maintenance
1	Plant buildings (reactor auxiliary building, control building, turbine building, service building, D_2O upgrading plant, waste treatment plant, switchyard etc.)		
	(a) Concrete and masonry structures	Underground water leakages in basement structures, cracks and spalling of concrete, abrasion of floor surfaces, cracks in masonry walls and plaster, damages due to chemical and oil spillages and weathering action, settlement of foundations, underscouring etc.	As a routine twice in a year; once during heavy rains and another after monsoon
	(b) Steel structures: columns, beams, stairs, ladders, handrails, hatch covers, partition, steel platforms and steel floors	General damages and dislocation, weld cracks, missing or loosened bolts, local damages to paint coating, dislocation of steps, handrails, hatch covers and gratings	Twice a year as a routine. Critical areas to be maintained immediately after any defect or discrepancy is noticed
	(c) Painting	(i) Distempers, acrylic emulsions and cement paints over internal concrete and plastered surfaces	Once in two years
		(ii) Synthetic and oil paints over steel structures	Once in three years
		(iii) Epoxy and vinyl paints over steel structures	Once in three years
		(iv) Epoxy coating over floors	Once in three years
		(v) Cement-based paint coating over external surfaces	Once in five years
	(d) Doors and windows	(i) Faulty operation, defective hinges, locks, aldrops, tower bolts, door closers, glasses, stoppers and general condition of doors and windows	Once in three months
		(ii) Repainting	Once in five years

TABLE A.2: SCHEDULE FOR ALL OTHER PLANT STRUCTURES (contd.)

Sl. No.	Structure/ Components	Items to be inspected and attended to	Frequency of inspection and maintenance
	(e) Rolling and sliding shutters	(i) Faulty operation, defective electric motor, wiring, limit switches, gear operation, oiling and greasing	Once in six months
		(ii) Repainting	Once in five years
	(f) Waterproofing of the building roofs	(i) Damage to waterproofing, cracks, bubble formation, damage to waterproofing on vertical face of the walls, expansion joints	Twice a year; once before and another during rainy season
		(ii) Cleaning of roof and roof drains	Twice in a year i.e. before rainy season and during rains
		(iii) Repairs/replacement of water proofing	Once in ten years or earlier
	(g) AC/CGI sheet of tilted roofs	Cracks, damage to bitumen, washers, bolts and nuts, general maintenance or replacement	Once a year before the rainy season
	(h) False ceiling	Breaking or dislocation of panels, panel supports and suspenders	Once a year
2	Underground trenches, tunnels and sumps	(i) Leakages, cracks and spalling of concrete, water logging due to improper slopes, leakages through construction and expansion joints, damage and dislocation of hatch covers, access ladders, damage to concrete and paint coating, cleanliness etc.	Before and during rainy season
		(ii) Repainting	Once in five years or as necessary

TABLE A.2: SCHEDULE FOR ALL OTHER PLANT STRUCTURES (contd.)

Sl. No.	Structure/ Components	Items to be inspected and attended to	Frequency of inspection and maintenance
3	Liquid storage concrete tanks other than SFSB	(i) Leakage from inside to outside and from outside to inside (in case of underground tank), cracks and spalling of concrete, access ladders, hand rails, platforms, manhole covers missing or broken	Once every year
		(ii) Repainting to external surface of the tank, repainting of steel structures	Once in five years
4	SFSB	(i) Leakage from inside to outside and from outside to inside (in case of underground tank), cracks and spalling of concrete, access ladders, handrails, platforms, manhole covers missing or broken	Once in six months (provision for monitoring should be made if design provision does not exist)
5	Cooling towers (NDCT and IDCT)	(i) Cracks and spalling of concrete, leakage from the pond, breaking or missing of fill material such as louvers, pipes, sprinkler, end plugs, hand rails	Repair and inspection to be taken during annual shutdown of the plant
		(ii) Cleaning of pond and sump and condition of protective painting	Once a year during shutdown
		(iii) Repainting of steel pipes and structures	Once in four years or earlier when necessary
6	Intake structure	(i) Damage to concrete structure	Once a year
		(ii) Settlement of pipeline, breaking of pipes and structure due to scouring action	Once a year
		(iii) Removal of silt from intake mouth, pipe lines and pump sumps	Once a year
		(iv) Repainting of steel parts	Once in five years

TABLE A.2: SCHEDULE FOR ALL OTHER PLANT STRUCTURES (contd.)

Sl. No.	Structure/ Components	Items to be inspected and attended to	Frequency of inspection and maintenance
7	Stack	(i) Condition of concrete wall surface.	Once a year
		(ii) Condition of access ladder, platforms in different levels on outside of the stack including surface treatments.	Once a year
8	Ion Exchange plant, DM plant, Raw water plant	(i) Condition of concrete columns, beams and roof	Once a year
		(ii) Condition of floor.	Once a year
		(iii) Condition of sumps	Once a year
		(iv) Condition of acid proof brick lining	Once a year
		(v) Critical examination wherever chemical spills involved	Once in three months
		(vi) Condition of waterproofing, rain water gutter, gratings at the inlet of down-comers	Before and during rainy season
9	Circulating water system and pump house	(i) Condition of concrete columns, beams and floor	Once a year
		(ii) Condition of masonry walls	Once a year
		(iii) Condition of concrete of valve pits and pump house for any corrosion	Once a year (during shut down)
		(iv) Condition of steel handrails, ladders, manhole covers etc.	Once a year
		(v) Condition of painted surfaces	Once a year
		(vi) Condition of waterproofing, rain water gutter, gratings at the inlet of down-comers	Before and during rainy season

TABLE A.2: SCHEDULE FOR ALL OTHER PLANT STRUCTURES (contd.)

Sl. No.	Structure/ Components	Items to be inspected and attended to	Frequency of inspection and maintenance
10	Access jetty	(i) Check surface and soffit of concrete decking and precast beams for any damage/erosion due to saline atmosphere	Once a year
		(ii) Check neoprene pads	Once a year
		(iii) Check deck top surface for any damages	Once a year
		(iv) Check for cathodic protection system for structural steel members to remain always in operational mode	Daily
		(v) Check fenders at the outside of concrete members of the intake structure for any damages	Once a year
		(vi) Check painted surface of steel members	Once a year
11	Roads	(i) Settlement, pot-holes, ruts and corrugations, disintegration of road surface, damage to culvert pipes, parapets, handrails, guard-stones, curbstones, footpaths	On continual basis throughout the year
		(ii) Cleaning road side drains, storm water drains including cross drainages	Before and during rainy season
		(iii) Water logging of roads	During rains and after rainy season
		(iv) Surface dressing or fresh carpeting to road surface	Once in five years or as necessary
12	Domestic water	Maintenance of bore wells/intakes, treatment plant, distribution network	On continual basis

TABLE A.2: SCHEDULE FOR ALL OTHER PLANT STRUCTURES (contd.)

Sl. No.	Structure/ Components	Items to be inspected and attended to	Frequency of inspection and maintenance
13	Sanitation and sewage disposal		
	(a) Toilets	(i) Leakages through distribution pipes and fittings such as taps, ball valves, flushing cisterns, overflow pipes, outlet pipes, cracks or breakage of wash basins, mirrors, urinals, water closets and other perishable toilet fixtures, pipe blocks, water hammer	On continual basis.
		(ii) Wearing off or breaking of floor and wall tiles	Once a month
		(iii) Availability of water	Daily before each shift
		(iv) Cleaning, washing and mopping	Daily before each shift
	(b) Sewage, drainage and disposal	(i) Cleaning of drainage system and repairs	Once a year
		(ii) Septic tank cleaning	Once a year or earlier as necessary
		(iii) Effluent from septic tank: check BOD and solid contents and condition of disposal	Once in three months
14	Stormwater drains within the plant	Check for entire system for any damages, obstruction to flow due to accumulation of debris, mud etc.	Prior to and during rainy season
15	Landscaping and plantation	Plantation, maintenance etc.	Continual basis
16	Security and property fencing.	Damage repairs	On regular basis

TABLE A.3: SCHEDULE FOR GENERAL HOUSEKEEPING

Sl. No.	Structure/ components	Items to be inspected and attended to	Frequency of inspection and maintenance
1	Active and non-active zones	Housekeeping including mopping	Daily before each shift
2	Non-active waste and garbage	(i) Collection and dumping at specified places	Daily
		(ii) Disposal through incinerator or burial	Daily
3	Station roads: including footpaths and side berms	Cleaning	Once a week

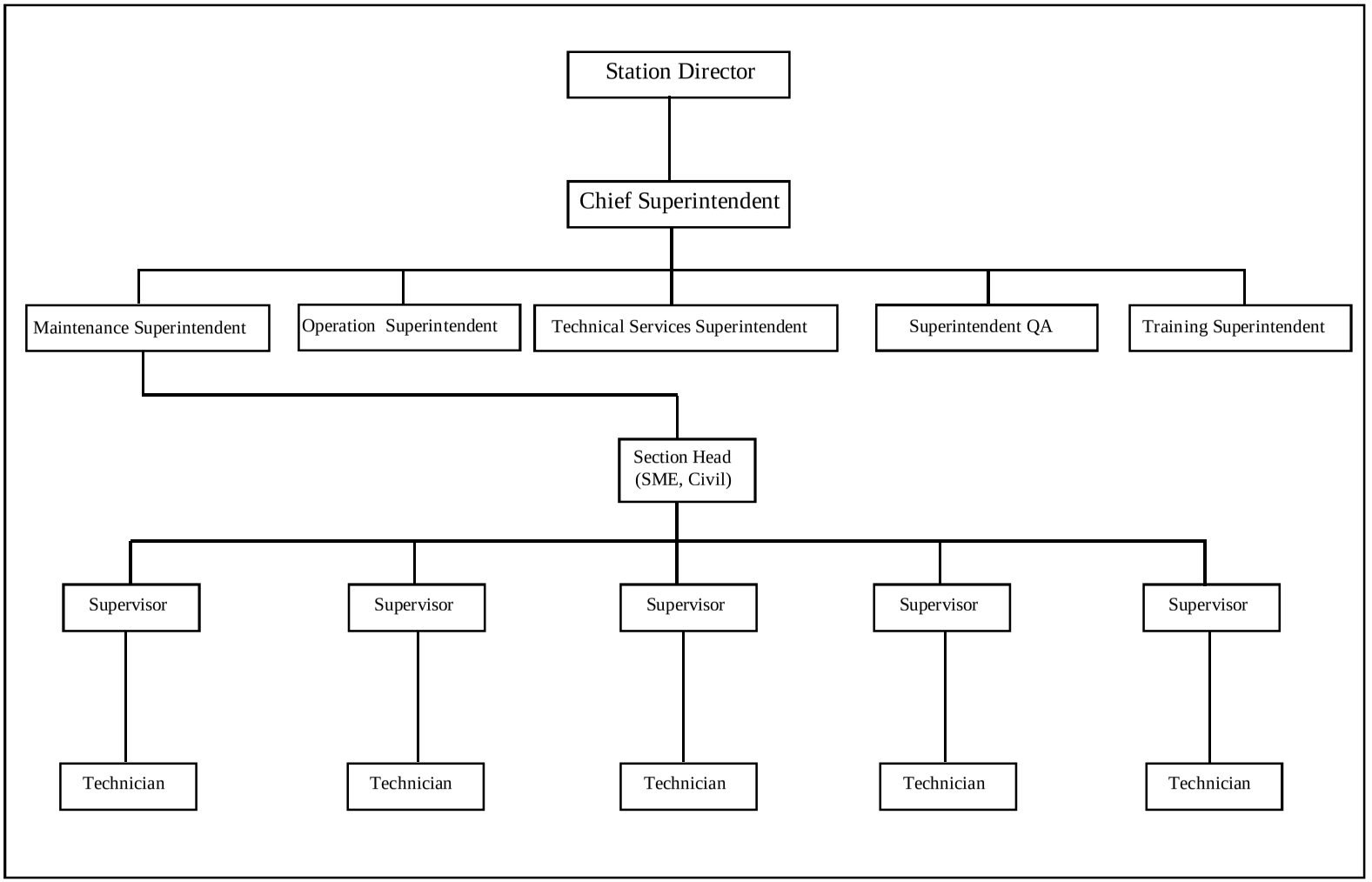


FIG 1: TYPICAL ORGANISATION CHART FOR CIVIL ENGINEERING MAINTENANCE WORK

REFERENCES

1. ATOMIC ENERGY REGULATORY BOARD, Safety Standard, Civil Engineering Structures Important to Safety of Nuclear Facilities, AERB/SS/CSE, 1998.

2. ATOMIC ENERGY REGULATORY BOARD, Safety Guide, Maintenance of Nuclear Power Plants, AERB/SG/O-7, 1998.

3. INTERNATIONAL ATOMIC ENERGY AGENCY, Maintenance of Systems and Components Important to Safety, Technical Report Series No. 268, 1986.

4. ATOMIC ENERGY REGULATORY BOARD, Safety Guide, Management of Nuclear Power Plants for Safe Operation, AERB/SG/O-9, 1998.

5. ATOMIC ENERGY REGULATORY BOARD, Safety Code, Code of Practice on Safety in Nuclear Power Plant Operation, AERB/SC/O, 1989.

6. ATOMIC ENERGY REGULATORY BOARD, Safety Guide, Radiation Protection During Operation of Nuclear Power Plants, AERB/SG/O-5, 1998.

7. ATOMIC ENERGY REGULATORY BOARD, Safety Guide, Staffing, Recruitment, Training, Qualification and Certification of Operating Personnel of Nuclear Power Plants, AERB/SG/O-1, 1999.

8. ATOMIC ENERGY REGULATORY BOARD, Safety Guide, Commissioning Procedures for Pressurised Heavy Water Reactor Based Nuclear Power Plants, AERB/SG/O-4, 1998.

9. ATOMIC ENERGY REGULATORY BOARD, Safety Guide, Seismic Studies and Design Basis Ground Motion for Nuclear Power Plants sites, AERB/SG/S-11, 1990.

10. ATOMIC ENERGY REGULATORY BOARD, Safety Guide, Geotechnical Aspects for Buildings and Structures Important to Safety of Nuclear Facilities, AERB/SG/CSE-2, (under preparation)

11. ATOMIC ENERGY REGULATORY BOARD, Safety Guide, Quality Assurance during Commissioning and Operation of Nuclear Power Plants, AERB/SG/QA-5, 1993.

12. ATOMIC ENERGY REGULATORY BOARD, Safety Manual, In-service Inspection of Civil Engineering Structures of Nuclear Power Plants, AERB/SM/CSE-2, (Under preparation).

13. NUCLEAR POWER CORPORATION OF INDIA LIMITED, Headquarters Instruction on Maintenance Manual for Civil Engineering Structures of Nuclear Power Plants, Issual - 456, 1995.

LIST OF PARTICIPANTS

CODE COMMITTEE FOR CIVIL AND STRUCTURAL ENGINEERING (CCCSE)

Dates of meeting	:	October 6 & 7, 1998 November 25 & 26, 1998 February 8 & 9, 1999 September 15 &16, 1999

Members and invitees participating in the meeting:

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Prof. V.N. Gupchup	:	Principal, VJTI, Mumbai, (Formerly)
Director (Civil Engineering)	:	Bureau of Indian Standards, New Delhi
Prof. A. Dasgupta	:	IIT, Guwahati
Shri R.B. Gunde	:	Tata Consulting Engineers, Mumbai
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ADVISORY COMMITTEE ON NUCLEAR SAFETY (ACNS)

Date of meeting	:	June 23, 2000.

Members and invitees participating in the meeting:

Shri S.K. Mehta (Chairman)	:	Director, RG, BARC (Formerly)
Shri S.M.C. Pillai	:	Nagarjuna Power Corporation, Hyderabad
Prof. U.N. Gaitonde	:	IIT, Bombay.
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Shri G.K. De	:	AERB (Formerly)
Shri K. Srivasista (Member-Secretary)	:	AERB

PROVISIONAL LIST OF CIVIL AND STRUCTURAL ENGINEERING STANDARDS, GUIDES AND MANUALS

Safety Series Nos.	Provisional Title
Safety Standards	
AERB/SS/CSE	Civil Engineering Structures Important to Safety of Nuclear Facilities
AERB/SS/CSE-1	Design of Concrete Structures Important to Safety of Nuclear Facilities
AERB/SS/CSE-2	Design, Fabrication and Erection of Steel Structures Important to Safety of Nuclear Facilities
AERB/SS/CSE-3	Design of Nuclear Power Plant Containment Structures
AERB/SS/CSE-4	Design, Fabrication and Erection of Embedded Parts and Penetrations Important to Safety of Nuclear Facilities
Safety Guides	
AERB/SG/CSE-1	Seismic Analysis and Qualification of Sructures, Systems, Equipment and Components Important to Safety of Nuclear Facilities (Being prepared by ACCGD as AERB/SG/D-23)
AERB/SG/CSE-2	Geotechnical Aspects for Buildings and Structures Important to Safety of Nuclear Facilities
AERB/SG/CSE-3	Quality Assurance for Construction of Civil Engineering Structures Important to Safety of Nuclear Facilities
AERB/SG/CSE-4	Materials of Construction for Civil Engineering Structures Important to Safety of Nuclear Facilities
Safety Manuals	
AERB/SM/CSE-1	Maintenance of Civil Engineering Structures Important to Safety of Nuclear Power Plants
AERB/SM/CSE-2	In-Service Inspection of Civil Engineering Structures Important to Safety of Nuclear Power Plants
AERB/SM/CSE-3	(Not to be published immediately)
AERB/SM/CSE-4	Civil Engineering Construction Inspection of Structures Important to Safety of Nuclear Facilities.
AERB/SM/CSE-5	Format of Safety Design Reports

NOTES