STANDARDS/MANUALS/ GUIDELINES FOR SMALL HYDRO DEVELOPMENT

1.8
General–
Project Management of Small Hydroelectric Projects

Sponsor:

Ministry of New and Renewable Energy
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Lead Organization:

Alternate Hydro Energy Centre
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PREAMBLE

There are series of standards, guidelines and manuals on electrical, electromechanical aspects of moving machines and hydro power from Bureau of Indian Standards (BIS), Rural Electrification Corporation Ltd (REC), Central Electricity Authority (CEA), Central Board of Irrigation & Power (CBIP), International Electromechanical Commission (IEC), International Electrical and Electronics Engineers (IEEE), American Society of Mechanical Engineers (ASME) and others. Most of these have been developed keeping in view the large water resources/ hydropower projects. Use of the standards/guidelines/manuals is voluntary at the moment. Small scale hydropower projects are to be developed in a cost effective manner with quality and reliability. Therefore a need to develop and make available the standards and guidelines specifically developed for small scale projects was felt.

Alternate Hydro Energy Centre, Indian Institute of Technology, Roorkee initiated an exercise of developing series of standards/guidelines/manuals specifically for small scale hydropower projects with the sponsorship of Ministry of New and Renewable Energy, Government of India in 2006. The available relevant standards / guidelines / manuals were revisited to adapt suitably for small scale hydro projects. These have been prepared by the experts in respective fields. Wide consultations were held with all stake holders covering government agencies, government and private developers, equipment manufacturers, consultants, financial institutions, regulators and others through web, mail and meetings. After taking into consideration the comments received and discussions held with the lead experts, the series of standards/guidelines/manuals are prepared and presented in this publication.

The experts have drawn some text and figures from existing standards, manuals, publications and reports. Attempts have been made to give suitable reference and credit. However, the possibility of some omission due to oversight cannot be ruled out. These can be incorporated in our subsequent editions.

This series of standards / manuals / guidelines are the first edition. We request users to send their views / comments on the contents and utilization to enable us to review for further upgradation.

Standards/ Manuals/Guidelines series for Small Hydropower Development

General	
1.1	Small hydropower definitions and glossary of terms, list and scope of different Indian and international standards/guidelines/manuals
1.2 Part I	Planning of the projects on existing dams, Barrages, Weirs
1.2 Part II	Planning of the Projects on Canal falls and Lock Structures.
1.2 Part III	Planning of the Run-of-River Projects
1.3	Project hydrology and installed capacity
1.4	Reports preparation: reconnaissance, pre-feasibility, feasibility, detailed project report, as built report
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1.6	Economic & Financial Analysis and Tariff Determination
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3.6	Technical Specifications for Procurement of Generating Equipment
3.7	Technical Specifications for Procurement of Auxiliaries
3.8	Technical Specifications for Procurement and Installation of Switchyard Equipment
3.9	Technical Specifications for monitoring, control and protection
3.10	Power Evacuation and Inter connection with Grid
3.11	operation and maintenance of power plant
3.12	Erection Testing and Commissioning

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PROJECT MANAGEMENT OF SMALL HYDROELECTRIC PROJECTS

1.0 SCOPE

This guideline covers different aspects of project management, planning and monitoring at various stages of project right from conception to completion.

2.0 REFERENCES

R1 Manual For Design, Implementation And Management For Micro-Hydropower Development, Department Of Energy Utilization Management Bureau, JICA, Philippines, June 2009

R2 Best Practices for Sustainable Development of Micro Hydropower in developing countries. Department for International Development, ITDG, UK, 2000

R3 Chauhan VPS, 2007, **"**Outsourcing of Project Management of Small Hydropower Projects", International Conference on Small Hydropower – Hydro Sri Lanka, 22-24 October 2007

R4 Small Hydro Power Hand Book Efficiency and Alternate energy Technology branch, Canada Centre for Mineral and Energy Technology, Energy, Mines and Resources, Canada,1986

3.0 NEED OF PROJECT MANAGEMENT

In order to implement the project, a project management team needs to be created and put in position to manage different aspects of the Project at different stages. These stages have been described below at 3.1. The hydropower projects are fraught with several external and natural risks such as Floods, Earthquake, Landslides and Social Unrest. These risks can be mitigated to a large extent by the experienced project management team. Until about a few years back almost the entire hydropower development has taken place in the Government Sector. A very few professionals have ventured out of the Government Sector to take up assignments in the private sector in India. The trend seems to be reversing slowly but surely. Nevertheless it is going to take some more time. Every individual looks for the job security but it is difficult for the small hydropower developers to provide comfort of job security and career enhancement prospective; and therefore, they do not find the right professionals to manage their projects and so the progress of work on these projects is slow. If the projects are managed by the right professionals then there is less risk and the project would be commissioned on time. The early commissioning means that the revenues start accruing early for the developer. The debt burden and the fixed expenses costs get reduced considerably.

3.1 Different Stages of Management

(i) Conceptualization of Scheme.
(ii) Setting up of Gauge Discharge Site.
(iii) Topographical, load assessment, power evacuation Geo-technical and Geological Surveys of the project area & the geological/hydrological investigations.
(iv) Confirmation of Layout on Ground including detailed survey.
(v) Identification of Land and preparation of land acquisition case.

(vi) Detailed Project Report (DPR) and Approval of the Detailed Project Report from the concerned Electricity Board or the concerned Government Authorities.
(vii) Financial Closure.
(viii) Design and Detailed engineering for the project.
(ix) Tender Documents for Civil works and E&M works.
(x) Construction and Commissioning.

3.2 Typical Components of Small Hydro Power Projects

(i) Diversion Weir/dam/barrage
(ii) Desilting Basin
(iii) Water Conductor System,
(iv) Forebay, Spill way and Penstocks
(v) Power House
(vi) Tail Race Tunnel or Channel
(vii) Switch Yard
(viii) Transmission line

4.0 PROJECT MANAGEMENT

Any SHP project will have many specialized and complex technical features and activities, timely execution of which shall require a comprehensive and integrated approach.

The key activities for appropriate planning and implementation of any such project are given in para 4.1

4.1 Key Activities

(i) Pre- project activities like Survey and investigations, Preparation of Pre-Feasibility Report, DPR, Project Cost Estimates and Preparation of Reports for Obtaining Clearances from various statutory agencies.
(ii) Project Planning, Base Engineering Design and Specifications.
(iii) Preparation of base documents for plant equipment and services. Preparation of tender documents, issue of NIT, receipt of tenders, evaluation and placing orders on identified vendors.
(iv) Creating infrastructure for receipt and storage of plant and equipment, material, consumables and special & ordinary T&P that are required for construction and commissioning of the project..
(v) Inspection of equipment at manufacturers work shops
(vi) Construction, Erection, Supervision and Management of all site activities e.g. progress management and quality assurance
(vii) Full range of project management services such as planning and scheduling, cost and schedule monitoring, control and generation of multi level information reports for different level of managers.
(viii) Project completion, commissioning trials and commissioning and
(ix) Demonstration of performance guarantees and warrantees.
(x) Carbon Credit validation, grant from MNRE and similar benefits.

4.2 Project Management Unit (PMU)

Thus , the project management is crucial for the timely completion of SHP.

The Project should be managed, monitored, and evaluated via a central project management unit (PMU) comprising staff put together by the executing agency and supported by the consultant, if required. The project management unit will be responsible for managing the Project and will undertake the following activities:

(i) Monitor the progress and work of the consultant.
(ii) Ensure timely completion of all milestones.
(iii) Implement and participate in the training programs.
(iv) Ensure that the necessary statutory approvals are obtained on time to advance project implementation.
(v) Provide oversight to procurement and contract management with assistance from the consultant.
(vi) Ensure that all environmental standards and regulations of the Government and funding agency are followed. Land acquisition and resettlement are not expected to be major issues, given that the SHPs are run-of-river projects and do not submerge the land. However, the Project involves construction of waterways (headrace and tailrace canals penstocks), powerhouses, and distribution lines that will occupy land. The use of productive land, including access, needs to be compensated. A suitable entitlement package should be developed after due consultation with all stakeholders and in accordance with relevant funding agency guidelines to adequately compensate each loss.
(vii) Monitor the progress and work of the contractors.
(viii) Certify completed subprojects testing and commissioning, with support from the consultant.
(ix) Verify invoices submitted by the contractors and recommend payments.
(x) Monthly progress reports submitted by the project management unit
(xi) Regular meetings between the project management unit, Government, funding agency & stakeholders.
(xii) Implementation and commissioning of SHPs with an aggregate installed capacity.
(xiii) Requisite reports (e.g., inception, progress, interim, completion, impact assessment, and audits) submitted on time.
(xiv) Capacity Building and Support of Community-Based Organizations comprising of following:-

a) Capacity building of staff, contractor and funding agency, and
b) Support for community-based organizations to assist in the day-to-day O&M of SHPs and to promote the establishment of small enterprises.

(a) Capacity Building

The entire project cycle is regarded as an on-the-job training where counterpart staff of contractor and funding agency should be closely engaged in project preparation and implementation. As part-I, the counterpart staff, mostly engineers, will enhance their capacities in planning, site reconnaissance, survey and design of SHPs, procurement and contract management. As part-II, the counterpart staffs are required to enhance their capacities in project management and contract management. Staff from all the developers including the State Government may also participate in specific training programs to prepare

themselves for the O&M of the SHPs upon completion. Capacity building with respect to O&M will deal not only with technical aspects, but will also cover metering, billing, tariff collection, and accounting.

(b) Support of Community-Based Organizations

Owing to the remoteness of the SHPs, community participation is required for day-to-day maintenance, including the clearing of trash racks and monitoring of waterways, and assisting in minor restorations. Community-based organizations need to be strengthened to undertake these tasks in cooperation. The Project will strengthen these community-based organizations once the projects have been selected for implementation. Depending on the nature of the SHPs, community-based organizations may be called upon to conduct metering, billing, and tariff collection on behalf of Government/vendors. In addition, community-based organizations will also be responsible for coordinating water usage for generating power, irrigation, and other purposes. During the implementation of the Project, the developer should provide trainings to the community-based organizations to build their capacities to undertake these tasks. The Project should also establish and strengthen small enterprises and other income-generating activities. Project support should target the community-based organizations and include activities such as setting up microfinance systems, providing business training for entrepreneurs, offering vocational and technical trainings, and teaching electrical safety or whatever is possible. Attractive returns to society and the country in terms of regionally-balanced growth, employment opportunities, capacity building at various levels, and poverty reduction. The projects may require small land donations for waterways and powerhouse structures. Any land requirements will first be discussed with the affected local community through public consultation and a commensurate compensation package will be provided. The developer should assist in addressing social and environmental safeguards in accordance with Government/funding agency guidelines. Similarly, environmental concerns that may arise during the implementation phase are addressed in the tentative environmental mitigation plan.

5.0 OTHER ASPECTS OF PROJECT MANAGEMENT OF SHPS

5.1 Community Empowerment

One of the factors behind pervasive poverty, especially in the vast rural areas, is a lack of employment opportunities. Electricity is indispensable to promote economic activities that in turn can create employment. However, the provision of electricity will not automatically give rise to economic development. Support must be extended to communities so that they can devise new business and effectively use electricity. At the SHP sites and supply areas, community-based organizations will be consulted with on development opportunities. The community-based organizations will decide among themselves appropriate allocation of river water for power generation vis-à-vis irrigation and other purposes. Although SHPs of size less than 500 kW may be difficult for community-based organizations to operate entirely on their own, they are expected to be entrusted with day-to-day maintenance and possibly also metering, billing, and tariff collection. Community-based organizations generally have their own traditional way of managing assets. For example, they normally collect money from each household to pay for maintenance and servicing of community assets. Once the SHP subprojects are identified, the developer should work in close cooperation with the executing agency and implementing agency, existing local bodies (e.g. community development councils), and local non government organizations (NGOs) to identify development opportunities. The developer should also provide technical assistance to

the community-based organizations and provide guidance on how the new SHPs can bring maximum benefits to the community.

5.2 Sustainability

5.2.1 Technical sustainability

The SHP system will use proven designs. The electromechanical equipment supplier along with the consultants will train local staff on the technical skills required for O&M through an on-the-job training program. The equipment operation and management training would be provided by the respective suppliers, whereas the consultant will provide training on metering, billing, tariff collection, accounting, and logistic support activities required.

5.2.2 Financial sustainability

The SHPs are expected to be profitable and financially self sustaining. The consultant will work out to establish a tariff structure comparable with that elsewhere in the country and affordable for lower income households. The consultant, along with the executing agency and implementing agencies, will design billing and collection procedures.

5.2.3 Environmental sustainability

The initial environmental examination and the Environmental assessment and review procedure, including the subproject selection and public consultation procedure, should be prepared. SHPs are environmentally clean as they

(i) do not combust fossil fuels,
(ii) do not emit gaseous pollutants,
(iii) do not generate solid or liquid wastes, and
(iv) can improve indoor air quality.

SHPs are usually run-of-river, without any reservoirs and with only a short waterway. The impact of an SHP on a river's ecosystem and the limit it places on other uses for water are insignificant. Nonetheless, the Project's environmental impacts should be studied further in accordance to relevant Government guidelines once the sites are identified.

5.2.4 Organizational sustainability

Government/IPP will be the owner of the SHPs. However, other modalities of operation will be considered, including O&M through a performance based lease contract and outsourcing day-to-day maintenance, metering, billing and tariff collection through community-based organizations. The optimum modality should be selected through a transparent process, and various training and capacity-building programs will be provided to ensure sustainability.

5.2.5 Risks affecting grant implementation

The major risks are security risks and institutional and governance risks, which are discussed herein.

(i) **Security Risks.** Ongoing conflict and general insecurity pose a major risk to the effective delivery of public services and other development activities. Insecurity is also a critical impediment to increased private sector investment, which has a negative

impact on employment creation. In addition to the difficulties created by insecurity with respect to field-level planning, implementation, and monitoring of development activities, poor security can increase the overall cost of development projects by as much as 20% due to direct security mitigation measures, high security-related salary and other personnel costs, and implementation delays of up to 1 year that can often result in cost overruns. To mitigate security risks, Government/funding agency strategy calls for making an increased effort to engage communities in project areas. With the involvement of local NGOs in community mobilization works and national contractors undertaking civil works (along with petty contractors and subcontractors from the local area), Government/funding agency community engagement strategy should be applied under the Project. In addition, Government/funding agency /NGOs will provide security advice and support to contractors in the development and implementation of project-specific security plans.

(ii) **Institutional and Governance Risks.** A second risk for funding agency operations is the Government's limited institutional capacity and weak systems of accountability.

Project specific risks are discussed in the Table 1 below:-

Table 1 : Project Specific Risks

Type of Risk	Brief Description	Measures to Mitigate the Risk
Safety and Security	General insecurity exists throughout the country; while the targeted areas may be relatively less volatile.	Closely monitor the security situation; adhere to Government approved security rules and regulations; engage local NGOs with work history in the target areas.
Governance	Lack of transparency and accountability of the implementing agencies and executing agencies; possible misuse of project funds.	Close monitoring of funds by funding agency and detailed approval procedures for specific project activities provides safeguards. Submission of audited annual financial reports and project progress reports by consultants will facilitate monitoring.
Weather and Road Conditions	Some areas are inaccessible from October to February because of heavy snow and poor roads.	Project planning schedules and appropriate time frame for activities.
Construction Delays	Procurement is difficult and time-consuming, which could delay plant commissioning.	Detailed plans and schedules are obtained in bid proposals; Penalty for being over budget or for late delivery. Government collaboration in import procurement
Inadequate maintenance after project completion	SHPs might not be properly operated and maintained after completion.	Proper training on O&M and involvement of community based organizations; lease agreement to private sector may also be pursued
Inadequate metering, billing, and tariff collection	Billing and revenue collection might not be properly carried out.	Selection of site will be focused on willingness to pay, affordability, and community- based organizations' involvement during construction and ongoing operation. Contractors will be asked to provide operating results for the next 3 years of operation after commissioning.

5.3 Fund Flow Arrangements

The disbursement procedure for eligible expenditures of fund must be in accordance with the Loan Disbursement Guideline (as amended from time to time) of the financing agency.

The project management unit under the executing agency will establish the imprest account. The imprest account will be managed, replenished, and liquidated in accordance with funding agency Loan Disbursement agreement and detailed arrangements will be agreed upon by the funding agency. The project management unit will prepare and submit the budget requirements for project activities to the executing agency. Upon approval of the consolidated requirements, the executing agency will submit to funding agency a formal request for fund release. The executing agency may request an initial advance based on approved contracts and planned expenditures for the first 6 months of the Project that are to be paid through the imprest account. The statement of expenditures (SOE) procedure will be used for reimbursement, liquidation, and replenishment of eligible expenditures. Some civil works and consulting contracts would be paid through the direct payments' system if required. The use of the imprest account and SOE procedure will be audited annually by auditors acceptable to funding agency. A separate audit opinion on the use of the imprest account and SOE procedure will be included in the annual audit report.

Replenishment will be subject to the liquidation of expenditures. The accounts should be replenished regularly to ensure that sufficient funds are always available. All withdrawal applications will be monitored by and approved in accordance with funding agency Loan Disbursement agreement. The designated commercial bank will provide monthly statements of the imprest account to the executing agency and project management unit, which will claim liquidation on the basis of the statement and other supporting documents.

An independent accountant will be engaged by the executing agency to conduct annual financial audits related to project implementation. Annual audits will be undertaken at the end of each year of the project implementation phase. Audit reports will be submitted to funding agency within 6 months of the end of each fiscal year throughout the project implementation period. Audit reports should include a separate audit on the use of imprest account and statement of expenditure procedure.

5.4 Implementation Arrangements

5.4.1 Entities involved

There are a large number of international and national advisors who are tasked with providing technical advice and consultations and other decision-makers. These factors build and add to the capacity to implement domestic/externally-funded projects. However, the Project will ensure that a strong project management unit is in place to support and bolster in their implementation efforts. The project management unit will have a head (specialist in hydropower development), a procurement specialist, an accountant/financial manger, and logistical support personnel.

The project management unit head and staff will be responsible to ensure that the consultant's activities are monitored in a timely fashion and project accounts are adequately maintained. The project management unit head will report to the executing agency, and will also coordinate with Government/funding agency.

5.4.2 Procurement and consulting services

The procurement and consulting services recruitment procedures shall be conducted in accordance with funding agency Guidelines.

5.4.3 Consultant staff

A necessary condition is job satisfaction. Consultants possessing work experience in remote areas, or other post-conflict areas, are preferred as they will be aware of their working conditions. However, to ensure that the area-based local staff has the tools and capacity needed to implement project activities, emphasis will be given to

(i) Developing reliable communications systems between project sites,
(ii) Providing training for staff, and
(iii) Bringing regional staff on a systematic basis.

5.4.4 Accounting, auditing, reporting, and project monitoring

Developer should prepare monthly and quarterly progress reports. The quarterly report will include descriptions and formative evaluations of the project activities implemented during the reporting period and planned activities for the next quarter. The project management unit will be responsible for compiling half yearly reports, to be submitted to the executive agency and funding agency. A project completion report will be prepared by the project management unit and submitted to the executing agency and funding agency within 3 months of the completion of the Project. The project management unit should also prepare a project replication assessment report and an implementation completion memorandum.

The executing agency shall maintain a separate project accounts for the funding agency grant. Annual financial audits shall be performed for the project accounts at the end of each fiscal year. Audit reports shall be submitted to within 6 months after the end of each fiscal year throughout the project implementation period and after the closing date of the project. The audit reports should include a separate audit opinion on the proper use of imprest account and the statement of expenditures.

5.5 Undertaking Various Project Management Services

The main objectives of Project management are the identification, planning, designing, and establishment of project. If the developer does not have sufficient and trained man power for Project Management then these services may be out sourced. To ensure sustainable management, capacity building project management is integrated as an essential component of the Project. The entire project management activity can be summarized in the following points:-

(i) Preparation of land cases.
(ii) Survey and design work.
(iii) Carrying out Geological Studies, Soil Testing, Detailed Surveys and Detailed Engineering Designing etc.
(iv) Preparation of detailed estimates along with the analysis of rates for various items of works involved.
(v) Project planning & scheduling and preparation of Detailed Project Report.

(vi) Preparing the cases for: Government Land Lease, Compulsory Land Acquisition, Forest Land Cases, Setting up of Discharge Sites along with Discharge Observation Process.
(vii) Preparation of Project Finance Documents and attain financial closure.
(viii) Seek advice on availing of CDM benefits (Carbon Credits)
(ix) Preparation of reply to the observations raised by the Sanctioning Authority in relation to Clearance of DPR of SHP.
(x) Preparation and finalisation of packages for Civil as well as Electro- Mechanical Works.
(xi) Obtaining Explosives Magazine License and provision of construction power. Construction power arrangement should be both an electricity connection from grid, if available and a DG set of required capacity.
(xii) Supervision & monitoring of construction activities in terms of quality control, adherence to execution drawings & project schedule. Review of drawings to suit the site conditions.
(xiii) Use of Project Management software like MS project, Primavera etc.

6.0 PROJECT IMPLEMENTATION/ MONITORING SYSTEM

6.1 Objective

- Record and report status of various components of project in such a manner as to bring the status of critical activities directly to the notice of concerned authorities.
- Highlight deviations in respect of various components of project to indicate the effect of such deviation on overall status and completion of project as a whole.
- To identify activities which are not going as per schedule and required to be brought to the knowledge of different levels of management for required corrective measures.

6.2 Design of Project Information and Monitoring System

It should spell out clearly:

- Objective of each format or report in brief
- The periodicity of report
- The timing of report
- Sources of information for preparing report
- By whom report is to be generated
- Authorities to whom report is to be sent

7.0 CONTRACT PLANNING AND SCHEDULING

Based on the time schedules indicated in the master PERT chart the contract schedule may be prepared indicating the time limits for achievement of the following milestones/ activities till the stage of award of contract:

- Technical specification, form of bid and standard condition of contract
- approval by competent authority
- issue of bid document
- opening of technical bid
- evaluation of technical bid and recommendations for financial bid opening

- opening of financial bid
- evaluation of price bids and recommendation for award of contract
- approval of recommendation by competent authority
- issue of letter of intent
- final contract agreement

Contract schedule for each contract shall for the basis of monitoring the contracting activities.

8.0 MATERIAL MANAGEMENT

8.1 Goals

The goal of materials management is to provide an unbroken chain of components for early completion of SHPs. The materials department is charged with releasing materials to a supply base, ensuring that the materials are delivered on time to the company using the correct carrier.

8.2 Quality Assurance

A large component of materials management is ensuring that parts and materials used in the supply chain meet requirements by performing quality assurance (QA). While most of the writing and discussion about materials management is on acquisition and standards, much of the day to day work conducted in materials management deals with QA issues. Parts and material are tested, both before purchase orders are placed and during use, to ensure there are no short or long term issues that would disrupt the supply chain.

A separate quality function generally deals with all issues concerning the quality of Concrete, Cement, and Aggregate etc for which if possible a small test lab should be established.

8.3 Materials Management Challenges

The major challenge that materials managers face is maintaining a consistent flow of materials at site. The major issues that all materials managers face are incorrect bills of materials, inaccurate cycle counts, un-reported scrap, shipping errors, receiving errors, and requirement reporting errors. Although there are no known methods that eliminate the afore mentioned inventory accuracy inhibitors, there are solutions available to eliminate the impact upon maintaining an interrupted flow of materials for production. One challenge for materials managers is to provide timely releases to the sites.

8.4 Benefits

The effective materials management plan builds from and enhances an institutional master plan by filling in the gaps and producing an environmentally responsible and efficient outcome. A power producer can expect a myriad of benefits from an effective materials management plan. For starters, there are long-term cost savings, as consolidating, reconfiguring, and better managing a site, core infrastructure reduces annual operating costs.

Overall the efficient Material Management shall contribute for the timely construction of SHPs.

9.0 CONSTRUCTION MANAGEMENT FOR CIVIL FACILITIES

9.1 Purpose

Construction management is performed by the contractor to satisfy the standards and to complete the construction works economically and safely within the construction period.

For assuring the quality and functions and for controlling the progress of work, the contractor makes a construction plan, checks in the middle of work whether the work is being carried out as scheduled, makes corrections if the work is delayed, examines whether the predetermined quality and shape are being made and shows the results on graphs and tables, corrects the items not meeting standards or the like, and records the progress, quality and shape of the work in comparison to the specifications and drawings. Construction management includes progress control, dimension control and quality control.

9.2 Progress Control

Progress control is the management of construction process for assuring the execution of work efficiently and economically within construction period by effectively utilizing the machines, labour and materials while maintaining sufficient quality and accuracy instead of merely controlling a series of processes for observing the completion date. In particular, in countries where a rainy season and a dry season can be clearly recognized, the construction works are concentrated in dry season and this will impose extra restrictions on time, and thus progress control must be given paramount importance. This is important because it is unavoidable to rely mainly upon manpower in civil works. On the other hand, hydropower station construction contains works for generator installation and electric facility construction in addition to civil works, and so close coordination between the works is required.

When using funds from international financial institutions for importing construction equipment and materials, various procedures are necessary to obtain approvals from relevant agencies for the import plan, to prepare documents necessary for international bidding, to make documents for bidding and contracting by export/import agents and to obtain approvals for export from the government of the country exporting the goods. When preparing a time schedule for construction, it should be noted that a considerable period of time is necessary from the start of taking the above procedures to the actual delivery of goods to the site.

9.2.1 Procedure of Progress Control

Progress control is made for each of the planning, implementation, reviewing and handling steps. Progress should be controlled to execute the works as close as possible to the schedule by carrying out the work in accordance with the construction schedule, and periodically recording the actual progress on schedule sheets every day, every week or every month and constantly checking the progress by comparing the planned and actual progress. If any large deviation is detected between the two, there may be a problem in the plan or implementation system. Thus, the plan should be reexamined and correcting measures taken. Then, implementation, reviewing and handling steps should be taken on the basis of the revised construction schedule.

9.2.2 Construction schedule chart

Various time schedules should be graphically prepared for progress control and then used as standard for implementation, review and handling. The following forms are normally used for the control chart.

(a) Horizontal line type schedule charts (Gantt chart, bar chart)
(b) Curve type schedule charts (graph type)
(c) Network type schedule charts (PERT, CPM)

Bar charts are normally used as schedule charts but the use of network type schedule charts is more advantageous in power station projects where various types of works overlap. For knowing the shape (dimensions, quantity, reference height, etc.) of an object created by the works, the shape is directly measured

9.3 Dimension Control

It is necessary to ensure that the civil works have been built in conformity with the contract requirements set forth and intended by the owner. If any items not meeting the requirements are found, the causes should be pursued and corrective measures taken. Dimension control can be roughly divided into direct-measurement and photo-graphic records.

9.3.1 Direct measurement

For knowing the shape (dimensions, quantity, reference height, etc.) of an object created by the works, the shape is directly measured in accordance with the sequence of construction works and the measured values are then compared to design values. The results are recorded, the accuracy of construction cheeked against standards, and the degree of construction technology controlled.

9.3.2 Photographic records

Photographic records are made as supplementary data for confirmation of the progress of the works at a later stage including conditions before and after the works, the portions that may not be seen upon completion of the structure, and the results of direct measurement.

9.4 Quality Control

Quality control is used to maintain the standards of quantity set forth in the design and specifications.

9.4.1 Procedure of quality control

For performing quality control, standardization must first of all be made. Standards or criteria should be established for all the phases ranging from material purchasing to work execution, and the works should be controlled in accordance with it.

(a) Standards for materials:Quality standards for materials to be used should be clarified and quantitatively defined.

(b) Quality standards: Control characteristics for the required quality should be clarified and quantitatively defined.
(c) Work standards: Facility handling standards, inspection standards and standards for working methods should be determined.
(d) Test and inspection methods: Standards for tests and inspections should be established.

As stated, it is necessary to establish material standards, use the materials of predetermined quality and perform the work, inspection and test in accordance with the predetermined methods satisfying quality standards.

9.4.2 Quality characteristics

Examples of quality characteristics and test items for the required quality control are shown in Table 2

Table 2 : Examples of Quality Characteristics

Kind	Quality characteristics	Tests
Concrete	Slump Air content Compressive strength Bending strength	Slump test Air content test Compression test Bending test
Earth	Grain size Degree of compactness Penetration index In situ CBR value	Grain size analysis Dry density test Various penetration test In situ CBR test
Asphalt	Density and voids Temperature at delivery to site Flatness of pavement surface	Marshall test Temperature test at delivery to site Flatness test

9.1.4.3 Control method

Typical quality control methods are as explained below.
(a) Histogram

For finding the distributing conditions of certain characteristic values of products, the measured values of required samples should be obtained and bar graphs prepared. Histograms are convenient for judging whether the quality characteristics satisfy the standards, whether the product distribution has certain allowance from the standards, and whether the distribution of the overall quality is appropriate.

(b) Control chart

Control charts have a wide application range, are useful among quality control methods and are therefore the most frequently utilized. Control charts show pairs of control limits and, if any plotted points are located outside the limit; this means that there is a critical quality fluctuation. Control charts are classified as shown below depending on whether the items being considered are continuous data such as length, strength and weight or discrete values such as fraction defective ratio, number of defective portions and number of defects.

Control charts for continuous data
.....X control chart, Xn control chart, R control chart, process capability chart.
Control charts for discrete values
..... P control chart, Pn control chart, C control chart, U control chart

10.0 MANAGEMENT OF INSTALLATION OF ELECTRO-MECHANICAL EQUIPMENTS AND AUXILIARIES

10.1 Planning of Erection of a Hydropower Plant

The entire process of erection, testing and commissioning may be divided into three main categories:

(i). Pre-erection activities to be completed before starting of erection of the plant.
(ii). Erection of built in parts of the plant.
(iii). Erection of main operating components of hydro set.

10.1.1 Pre-erection activities mainly cover following

(i) Preparation of a plan to carry out erection work and sequence of different activities.
(ii) Preparation for site storage consisting of open, closed, semi closed storage and construction of roads, accesses for delivery of plant to assembly area.
(iii) Methods of preservation during storage to be provided by the manufacturer.
(iv) Erection of temporary structures, living quarters necessary for carrying out site work smoothly and speedily.
(v) Site office facility- temporary/ permanent.
(vi) Arrangement of construction power, water, compressed air for the erection activities. DG sets of adequate capacity to be kept as stand by in case of power failure.
(vii) Arrangement of lighting of erection site and nearby area.
(viii) Ensuring sequential delivery of equipment and materials necessary for continuity of erection work as per charts and plan.
(ix) Providing hoisting arrangement, handling mechanisms, tools and devices for erection as also making arrangement of transportation of material to the site. The material will be unloaded in unloading bay and shifted to pre identified place.
(x) Arrangement of safety measures protection of workers and equipment during handling, shifting and installing different components of plant.
(xi) Arrangement of first aid and health checkups for workers.
(xii) The contractor shall institute a health, safety and environment management system for his operations. Such system shall identify the health and safety aspects of contractors activities and provide for the monitoring of the health and safety performance.

10.1.2 Erection of Embedded Turbine Parts

Erection of these items starts as soon as the underwater concrete structure has reached the required elevation below the lining of DT cone. At this stage permanent crane is not available as such temporary gantry crane has to be installed whose lifting capacity, travel upward, downward, forward and backward is decided by the size and weight of heaviest and largest part to be handled by the crane.

10.1.3 Erection of main operating components

Erection of main components of unit is started only after permanent crane is made available. As such civil works are planned in such a way that availability of main crane matches with the start of assembly and erection of main plant.

10.2 Planning and Monitoring of Erection Activities

Erection work usually is planned in two stages:-

10.2.1 The first stage

(i) In first stage a well coordinated overall plan for construction of civil activities and activities related to erection of hydro mechanical items and hydro generating units is prepared as bar chart. Bar Chart for a typical R.O.R. SHP is shown in Fig 1.

(ii) A PERT/CPM is to be developed for monitoring of ongoing activities and critical activities to avoid any slippage of schedule. PERT chart for a typical R.O.R. SHP is shown in Fig 2.

10.2.2 The second stage

This is the detailed planning stage and it should include following information concerning erection of main equipment.

(i). The quantum of work to be done under the installation works and which is required to be completed by monthly schedule according to overall coordinated construction schedule of the project should be prepared.

(ii). Major activity wise PERTs are developed showing sequence and duration of activities matching with delivery schedule and civil construction activities for monitoring by the in-charge of erection works. This should give sequence and duration of all critical as well as parallel activities for completion of erection work as per overall schedule. The in-charge should have following important information with him

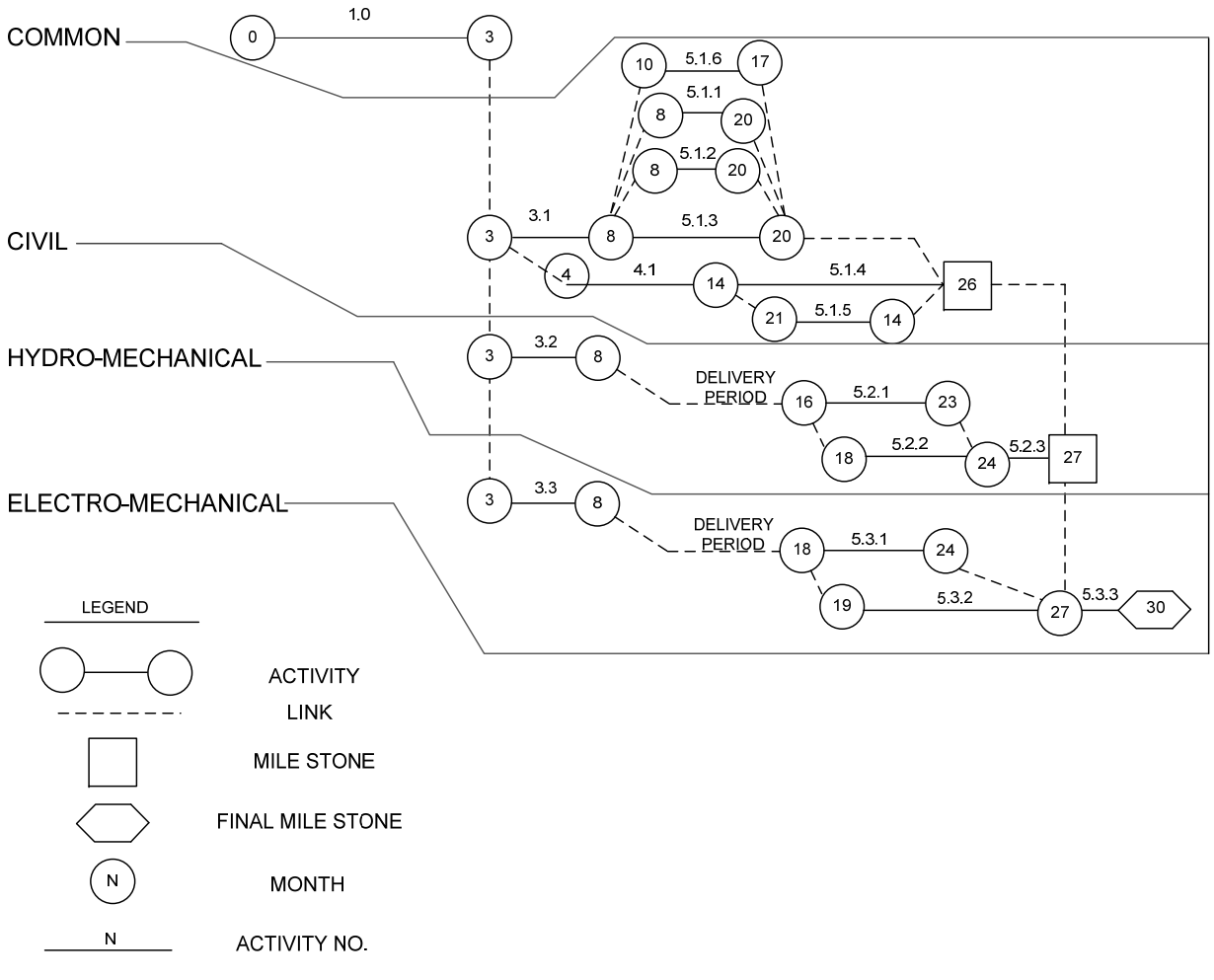
(a) The technological process of assembling and erection of unit.
(b) Requirement as regards workers, engineers, and technicians.
(c) Basic material and their expected deliveries to the site.
(d) The technical features of main equipment, weight and size parts and subassemblies.
(e) Plan for labor requirement and their movement.
(f) All relevant plan, assembly and erection drawings
(g) Requirement of hoisting arrangements required for all subassembly and assemblies.
(h) Requirement of tools, material, equipment, electrical energy, compressed air.
(i) Requirement of special tools devices essential for erection work.
(j) Requirement and arrangement of safety and industrial health measures.

Fig 1 : Bar Chart - Construction Programme of A Typical Run of River SHP Project

S. No.	ACTIVITY	MONTHS																												
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1.0	**Study of approved DPR, all Government and statutory clearances, documents of land acquisition etc.**																													
2.0	**Preparation of tender documents**																													
2.1	Technical Specifications and drawings of civil works																													
2.2	Technical Specifications of E&M works																													
2.3	Review of tender document																													
2.4	Finalisation of tender documents																													
3.0	**Invitation of bids and finalisation of order for civil works, hydro-mechanical works and E&M works**																													
3.1	Civil works																													
3.2	Hydro-mechanical works																													
3.3	E&M works																													
4.0	**Detailed engineering design and construction drawings**																													
4.1	Detailed engineering design and construction drawings for civil works																													
4.2	Checking of vender specifications and drawings for E&M works																													
5.0	**Execution of works**																													
5.1	Construction of Civil works																													
5.1.1	Diversion Weir																													
5.2.2	Head race channel																													
5.1.3	Tail race channel																													
5.1.4	Power house building																													
5.1.5	Construction of machine foundation in power house building – RCC work																													
5.1.6	Diversion channel and spillway																													

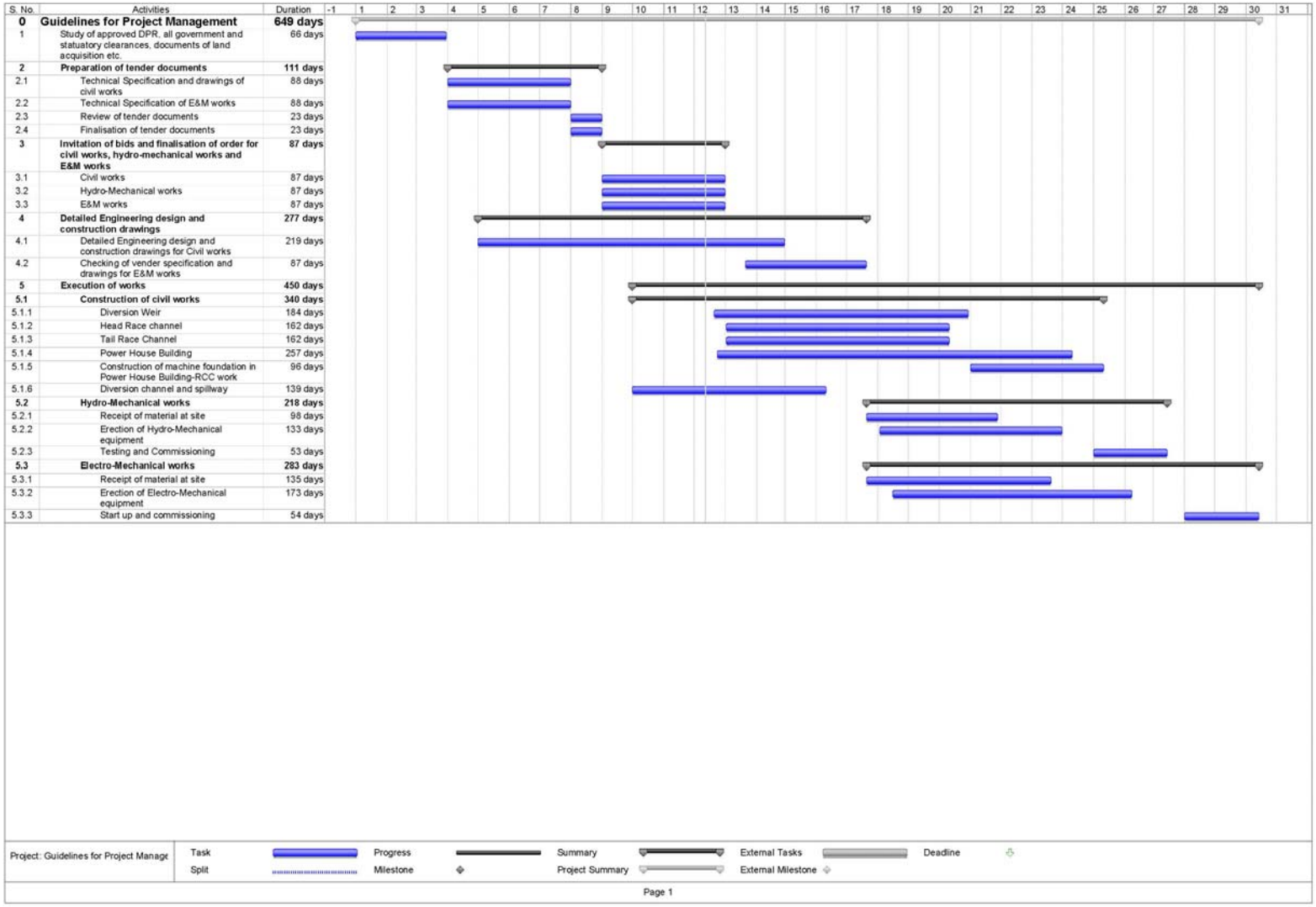
5.2	**Hydro-mechanical works**																													
5.2.1	Receipt of material at site																													
5.2.2	Erection of hydro-mechanical equipment																													
5.2.3	Testing and commissioning																													
5.3	**Electro-mechanical works**																													
5.3.1	Receipt of material at site																													
5.3.2	Erection of electro-mechanical equipment																													
5.3.3	Start up and commissioning																													

Fig 2: PERT Chart - Construction Programme of Typical Run of River SHP Project



S. No.	Activity
1.0	Study of approved DPR, all Government and statutory clearances, documents of land acquisition etc.
2.0	Preparation of tender documents
2.1	Technical specifications and drawings of civil works
2.2	Technical specifications of E&M works
2.3	Review of tender document
2.4	Finalization of tender document
3.0	Invitation of bids and finalization of order for civil works, hydro-mechanical works and E&M works
3.1	Civil works
3.2	Hydro-mechanical works
3.3	E&M works
4.0	Detailed engineering design and construction drawings
4.1	Detailed engineering design and construction drawings for civil works
4.2	Checking of vender specifications and drawings for E&M works
5.0	Execution of works
5.1	Construction of civil works
5.1.1	Diversion weir
5.1.2	Head race channel
5.1.3	Tail race channel
5.1.4	Power house building
5.1.5	Construction of machine foundation in power house building – RCC work
5.1.6	Diversion channel and spillway
5.2	Hydro-mechanical works
5.2.1	Receipt of material at site
5.2.2	Erection of hydro-mechanical equipment
5.2.3	Testing and commissioning
5.3	Electro-mechanical works
5.3.1	Receipt of material at site
5.3.2	Erection of electro-mechanical equipment
5.3.3	Start up and commissioning

Fig 3: Gantt Chart – Construction Programme of Typical Run of River SHP Project



10.3 Recording of Erection Work and Technical evaluation

A record of the work carried out must be kept during erection. This record should contain:-

(i) Brief technical details of equipment with the name of supplier.
(ii) Descriptions of the main stages of work and date when started and finished.
(iii) Records of shortcomings in the equipment noticed during erection and of the action taken.
(iv) Records of shape checking and other log sheets recorded during erection works.
(v) Records of quality checks during erection works as per QAP to be signed by Owner's Erector's representatives.
(vi) Records of all field tests done before and after charging of water conductor system
(vii) All instructions passed on to the technicians during process of progress of erection work.(Separate instruction register to be maintained)
(viii) Alterations, deviation made in various erection drawings during progress of erection work after completion of the contractor to submit as built/ as made drawings.
(ix) Photographs of various important erection activities with dates for visual records of progress.
(x) Sketches and drawings of innovative techniques, tools or devices used during erection work with material details.

The technical evaluation of erection of main equipment is compiled from the original documentation for each generating set separately after it has been put in service. The evaluation must indicate the conditions, process of erection accompanied by explanatory records with diagrams and photographs. The explanatory records should contain following:-

(i) Brief power and design characteristics of the equipment with data.
(ii) Data on the weights of generating set, separate mechanisms, sub assemblies and main parts.
(iii) Remarks concerning completeness of equipment supplied.
(iv) Shortage and short comings list. Master shipping list to be given by Supplier to ascertain shortages in different packages received at site
(v) Availability and quality of manufacturers' technical documentation, plans for installing of equipments etc.
(vi) Details of hoisting devices, innovative devices used during erection.
(vii) Technological processes used during erection (planned actual).
(viii) Description of new advanced work procedures used during erection.
(ix) The nature of simultaneous construction and erection work.
(x) Number of engineers, technicians and workers employed during various assembly and erection activities (total and by qualification).
(xi) A summary of manufacturing defects in the equipment, the amount of work and cost involved in action taken.
(xii) A summary of cost in installing each hydro set.
(xiii) Measured operating characteristics of generating set (power, governor response) during acceptance test when the equipment is put into operation.

(xiv) General conclusion in installing of the hydro generating set in the plant.

(xv) Drawings of generating set (sections) charts of installation work (directive and performance) photographs and plans of typical operations during assembly and erection.

(xvi) Sketches and drawings of innovative tools and devices for assembly and erection of generating set.

11.0 QUALITY ASSURANCE MANAGEMENT

There are following five stages of project where quality assurance monitoring is essential;

(i) Design stage
(ii) Procurement stage
(iii) Site material
(iv) Construction stage
(v) Commissioning stage

11.1 Design Stage

The design has to be right before finalization of specification for placement of order on the manufacturer/supplier. Quality assurance design control plan should be such that it meets the needs of contractual scope of work. Therefore:

(a) Work scope, specification, design criteria, regulatory requirements should be properly understood.
(b) Proper Q.A. standards for document preparation and approval should be prepared
(c) Design check is carried out to verify content and accuracy of a document. Checking engineer should not be the same person who carried out the original work.
(d) Checking accuracy and content is not sufficient but also should assure compatibility between all disciplines (civil, structural, electrical mechanical architectural etc.) involved.
(e) Q.A. should cover change control also. All changes must be documented and reviewed in the systematic manner as original documents. There should be a schedule for these reviews in the document.

11.2 Procurement Stage

(i) Inspection, checks and tests at procurement stage are very important
(ii) It will identify all inspection check points relevant to the criticality of the equipment
(iii) It will also identify requirements for non-destructive tests, acceptance tests, certification and documentation.
(iv) It will also identify mandatory hold points, beyond which supplier can not proceed unless cleared by the competent authority
(v) Quality control activity should be reviewed with supplier for ensuring quality of material.
(vi) There should be a schedule for these reviews in the document.

11.3 Site Materials Quality Assurance

It should be ensured that there are satisfactory arrangements for the following:

(a) Examination of the material upon receipt at site to check

- Quantities
- Identity
- Damage during transit

(b) Periodic inspection during storage to detect any sign of deterioration, out-dating risk where storage time exceeds the self life and to ensure that material is stored as per instruction of supplier.

(c) Compliance of any contractual requirement of inspection

(d) Appropriate identification of material and safeguarding of material against unauthorized use or disposal.

(e) Procedure should be laid for reporting any shortage, damage, material unfit for use to the competent authority.

11.4 Construction Stage

Quality control during construction of project is very important because this will ensure smooth operation and optimum generation from the project. All construction activities require meticulous supervision.

Quality Assurance Plan covering checking stages , check points and preparing log sheets to be filled at various stages are required to be prepared by construction agency and got approved by Owner's competent authority.

The processes which need quality inspection and control are as follows:

-concrete mixing
-welding
-casting
-heat treatment
-various stages of installation of plant

It will have to be ensured that these processes are carried out in controlled conditions by qualified personnel using calibrated equipment in accordance applicable codes, specifications, standards regulatory requirements etc.

It will have to be ensured that setting elevations, centering of unit axis, positioning various equipment in power station and other such critical activities are carried out in controlled conditions by qualified personnel using calibrated instruments in accordance applicable codes, specifications, standards regulatory requirements etc.

11.5 Commissioning Stage

QAP for commissioning stage is required to be prepared and implemented in such a way that attainment of quality of all activities and functions are achieved in most efficient manner.

12.0 HUMAN RESOURCE MANAGEMENT

The overall objective of Human Resource Management is to improve both technical and institutional aspects of the SHP to be constructed:

The availability of well-trained personnel is a key requirement in the hydropower sector. The education and training task force should be aimed to planning of hydro power projects aiming for timely and quality construction of SHP. Workers and Project leaders should be informed about the benefits and limitations of small hydro power construction, plus their responsibilities and actions desires in this respect. Additionally, some basic information should also be provided to site engineers.

(i) Owners/managers should be trained in various aspects of Civil and E/M works.

(ii) Workers should be trained for operation and maintenance procedures who will be responsible for O/M of Plant in due course of time.

(iii) Mechanics/technicians (e.g. from nearby workshops) should be trained in various aspects of plant machinery, its functioning, assembly and so on, so that they can undertake temporary repairs of T and P ate site if possible.

13.0 COORDINATION AT DIFFERENT LEVEL

The Project Leader has to coordinate among various levels. He needs to:

(i) Monitor and report the periodic progress to the monitoring office.

(ii) Address all the issues local habitants, local bodies and local administration for smooth and continuous construction activity.

(iii) Coordinate with the person responsible for Material Management.

(iv) Coordinate with the contractors engaged for different contract agreements.

(iv) Coordinate with the legal authorities for the compliance of statutory obligations and to address the legal issues encountered if any.

(v) Coordinate with the District level and State level Government authorities responsible for the statutory clearances required for the Development and Implementation of SHPs.

(vi) Compel all the Contractors engaged for Construction to comply for the statutory requirements.

(vii) Coordinate between the construction people and Designers.

(viii) Decide and resolve all the issues emerging due to the difficulty faced in the implementation of design drawings.

14.0 MANAGEMENT OF SAFETY ASPECT DURING CONSTRUCTION OF PROJECT

(i) Every power plant shall prepare a safety manual prior to start of works, copies of which shall be given to every employee. The safety manual shall contain:

(a) Safety policy of the organization
(b) Safety during various construction activities.

(ii) The management shall conduct safety training for construction engineers and staff on regular basis.

(iii) The safety equipment such as helmet, welding goggles, hand gloves, insulated T&P for electrical works, earthing chains /earthing rod, safety belt, rain coat, gum boot etc. shall be kept at the location where these can easily be accessed.

(iv) The arrangement to supervise implementation of safety plan shall be made at each P.S.

(v) Guidelines for safety in working are to be given in detail in safety manual.

(vi) Fundamentals on Safety :

Prevention of accidents requires whole-hearted co-operation of all members of the organization. A capable, mentally alert and trained employee will avoid accidents. However an unsafe person is a liability. He is danger to himself, his fellow workers and to the equipment and organization.

(a) Unsafe acts which may cause accidents:
    (i) Operations of equipment without authorization.
    (ii) Making safety devices in operative.
    (iii) Using defective equipment or its improper use.
    (iv) Working nearby dangerous or live electrical equipment which could conveniently be de-energized.
(b) Unsafe conditions which may cause accidents:
    (i) Ungrounded equipment.
    (ii) Defective or non standard material or equipment or T & P.
    (iii) Improper illumination.
    (iv) Non-standard design or construction.

Hence, accidents are the results of unsafe conditions or unsafe acts or combination of both.

15.0 DISASTER MANAGEMENT

Disaster management is aimed at ensuring safety of people, protection of environment protection of installation and restoration of generation.

(i) A task force consisting of erection personnel of different discipline needs to be constituted who will identify the following:
    (a) Source of disaster and steps to contain the same.
    (b) Isolate safe portions of project and ensure their safety.
    (c) To organize all support services like fire fighting system etc.

(d) Attend to all emergencies on top priority.
(e) To apprise authorities on all safety related issues.
(f) To record accident details.
(g) To arrange for evacuation of man, material from affected area.
(h) Arrangement of ambulance and emergency first aid.

(ii) The disaster management plan for power projects under construction shall take care of the following:
(a) Information to management on urgent basis.
(b) Emergency power supply system shall be made operational.
(c) In case of fire, isolate the location and ensure immediate fire fighting measures so that it may not spread to other areas.
(d) Fire tenders need to be summoned immediately.
(e) The earmarked hospital need to be informed of such emergency.

(iii) Action Plan
For effective control and management of disaster an action plan and organization shall be prepared by Project in-Charge along with responsibilities apart from training of personnel for handling of such situations. This shall consist of following factors:
(a) Responsibility of employees about first information.
(b) Responsibility of Emergency Management Manager (EMM) for declaration of emergency (EMM to be nominated by Plant In-Charge).
(c) Responsibilities of various teams constituted to deal with specific emergency requirement.
(d) Responsibility of EMM for "All Clear" signal after disaster has been cleared off.

(iv) Essential Staff
In portions of project immediately affected or likely to be affected efforts will be made to make other areas safe. The engineers and supervisors will carry out this work with the help of trained staff without exposing them to any risk. The following staff will also help them:
(a) Attendants
(b) First aiders (if available, otherwise all staff should have proper training for first aid)
(c) Persons responsible for emergency lighting
(d) Persons responsible for transport
(e) Persons working as runners, in case communication fails
(f) Liaison with district administration, fire tenders, call for emergency vehicles, ambulance, to control traffic leaving and entering project site to turn away visitors and non-essential vehicles.

It is responsibility of EMM to identify such staff and form task force to carry out above activities. In case separate staff for carrying out such activities is not available, existing staff should be trained for these eventualities.

(v) Disaster Possibility in Hydro Power Projects
(a) Disaster due to natural calamities such as floods, earthquake, landslides and wind storms which may affect outdoor installations.

(b) Areas prone to disaster on account of fire are cable galleries, switchyard and switchgears, transformer, oil containers, generators/motors and records etc.

(c) Failure of underwater structures due to inadequate support or geological reasons.

(d) Failure of scaffoldings

(e) Non -clearance of debris under the location where over head welding is being done

(f) Non- removal of packing material as soon as the components are unpacked

Project staff should remain always alert for such emergent eventualities. Project In-Charge should arrange drills, training for the staff at regular interval especially before rainy season.