



## Chapter 6

# Managing Project Quality

### 1. Introduction

In order to ensure quality throughout the various stages of the project, as stipulated in the performance objectives established by the client institution, a project quality management program should set out in writing the scope of the activities to be carried out by the various professionals and firms involved, as well as the criteria they should meet, based on quality assurance standards such as those set by the International Organization for Standardization (ISO).

Such a document must specify the quality assurance activities that shall accompany the project development stage, the selection of the professionals, and the activities aimed at risk assessment, site selection, project design, tendering processes, construction, and project oversight. It should also define explicitly the functions and responsibilities of the parties and the oversight and follow-up mechanisms. Such a document must be drafted clearly, without ambiguities that might lead to errors of interpretation, in line with the general principle that the quality assurance program (QAP) should be guided by preventive, rather than corrective, measures.

The client institution must ensure that all project participants are fully aware of the provisions contained in the QAP. It must also ensure that they are met. Such a quality assurance program, in tandem with the safety certifications required at the various design and construction stages of the project, should contribute significantly to fulfilling the performance and other objectives set out for the intended facilities.

## 2. Guiding principles for the review and inspection of the project

Since the high performance objectives required by health facilities call for highly qualified specialists, professionals, technicians, and laborers, as well as special assessments and the production of detailed drawings and specifications, it is essential to implement systematic review and inspection procedures. Such procedures will generally require higher standards than those applied to ordinary construction projects.

At each stage of the project cycle, for instance, ongoing independent monitoring should be carried out for each discipline involved. Attention must also be paid to the degree of synergy achieved by those disciplines. The purpose of such monitoring is to ensure that the project components for which each team is responsible are compatible with each other. Another virtue of this approach is that it can identify weaknesses in the implementation or coordination of the project, reducing the risk of not meeting the performance objectives for the facility.

The oversight team should specify in writing their review and monitoring procedures. Reporting dates should be set in advance, based on the project design and construction program. The various professionals involved in the project must be aware of such dates, so that their actions can be coordinated, reviewed and, if necessary, corrected.

Before the final drawings and specifications are issued, each team of specialists must produce a work program, in writing, to be handed out to the other teams in order to facilitate a final round of cross-checking regarding disaster mitigation measures. Every review, inspection and testing mechanism to be employed in the project must also be stated in the document. The procedures to be applied should explicitly heed existing standards, and their application must be documented. No undocumented procedures are to be tolerated.

Histograms and other project management tools should be used to set the start and completion dates for the execution and delivery of each component. Communication channels and protocols must also be defined in advance. Each team must have access to up-to-date reports on how the project components managed by the other teams are advancing. The project monitoring team must call for periodic coordination meetings of the heads of teams in order to review the progress achieved and any problems that may affect the other teams' performance.

Whether during the design or construction stages, every modification to the original concept, including changes in methods or standards used, must be documented and conveyed to the other disciplines involved.

Every project whose performance objective is functional or investment protection must compile as-built reports on the progress of the works. The same is true if the objective is life safety, should the client institution require it.

Every modification to the original project must be approved in writing by the client institution. Every modification to the works during the construction stage must be approved in writing by the building contractor, the project inspectors and the relevant teams of specialists, and it must be recorded in the as-built reports.

The following sections cover specific quality assurance issues that must be considered during the various stages of the project.

### 3. Project quality assurance during the preliminary and design stages

The project's quality assurance program (QAP) must specify the tasks required to ensure the quality of the project during the preliminary stage, including the various risk assessments and the actual design of the facilities. This document must state the performance objective expected by the client institution, based on the criteria listed in *Chapter 2* in connection with the project's design philosophy.

Start and completion dates for the various risk assessment studies must be set in advance, so that the project design team can benefit from these inputs when incorporating disaster mitigation measures. Likewise, a histogram should be produced showing the progress required of all disciplines at any given date, so that their interaction can be effectively coordinated and corrections can be made to prevent haphazard phasing of the project or its use of resources.

At a minimum, the contract must state that the following documents will be subject to review and monitoring:

- Records of quantities and overall budget;
- General drawings and specifications;
- Architectural and structural drawings and specifications;
- Detailing plans;
- Equipment, installation, and furnishing plans.

Other tender documents should also be reviewed, including the technical specifications, equipment installation procedures, the construction manual, the manual of procedures, the construction schedules, and the general contractual terms and conditions.

Special attention must be paid to the detailing plans and respective financial reports on all the components of the building, in order to verify that the final design will match the performance objectives sought by the client institution. The professionals in charge of designing the project must specify which procedures, components, or services will require general inspections or spe-

cialized inspection during the construction stage. They should also state the characteristics of the inspections required.

*Annex 6.1* summarizes the minimum requirements of a quality assurance program (QAP) to guarantee the quality of the project during its preliminary and design stage.

## 4. Project quality assurance: The construction stage of the project

Well-documented procedures guarantee the quality of the project during the design stage. The same is true at the construction stage. Accordingly, a compendium should be drawn up containing the specifications and other information that can ensure quality during the construction process. This compendium must contain all information needed to start construction of the intended health facility, including the final, approved drawings and specifications, the tender documents and the signed contract.

The quality assurance program must identify all professionals, consultants, and contractors who will participate in the construction. It must define the roles and responsibilities of all stakeholders, including the teams that participated in the design stage.

The client institution and the execution and review teams must fulfill the following obligations: delivering to the contractor a feasible project; making interim and final payments based on agreed-upon methods and dates; providing a suitable site that meets project requirements; choosing the correct mechanisms for inspecting the quality of the work, materials, and so on; taking the lead in decision-making when unforeseen circumstances arise; communicating in timely fashion to all parties any changes to the original project; and monitoring the progress of the work.

During the construction stage, it will be the responsibility of the design team to assist in the inspection of the work they designed, help in decision-making when unexpected circumstances or aspects not contemplated in the contract documents arise, assess the merits of any variation the contractor may propose, participate in specialized on-site inspections, certify the satisfactory completion of the various components, and recommend that interim payments be made. Either the client institution or the design team may recommend that the work be stopped or payments held back if the performance and quality objectives set for the project are not being met.

The contractor's functions will include, at a minimum: taking all the administrative and legal steps needed such as securing permits, reviewing the architectural, structural, nonstructural, equipment and detailing drawings and specifications; being faithful to these specifications; requiring that providers issue quality and safety certificates; controlling the pace of the work and the use of the resources allocated for the project; carrying out all quality assurance tests needed; keeping a builder's log; producing regular reports on the progress of the work; and any other requirements contained in the contract documents. It will be the contractor's duty to be fully

aware of the objectives and details of the project; acquire materials and hire workers that meet the quality requirements of the project; take responsibility for the subcontractors' work and for the building methods and schedules applied; update the builder's log regularly and make it available as required; and report the results of any tests in a timely fashion to the client institution, project administrator, works inspectors, specialists, design team, and external inspectors.

The function of the inspection team (or teams) is to act on behalf of the client's interests by ensuring that the construction methods, materials and labor supplied meet, at all times, the standards required by the project's performance objectives. The tasks required of the inspectors in the course of the contract include making sure that the construction program is being met according to the agreed-upon start and completion schedule, reviewing the construction methods employed by the contractor, reviewing the builder's log regularly, inspecting the quality of the building materials and labor employed, providing technical assistance to the contractor in specific areas, monitoring the work of the external inspectors, participating in critical decisions regarding contingencies, defining when payments are to be made, verifying that safety measures are taken, and safeguarding and controlling the contract documents and test reports. The inspection team must be fully aware of the objectives and details of the project, know the standards applied during the design, be familiar with construction processes and the project contract and subcontract documents, and remain in constant communication with the client institution.

In order to ensure the quality of the materials and procedures employed, the QAP must include a detailed program of inspections and tests listing the deadlines for these inspections and tests and the responsibilities of the external bodies in charge of such activities. These entities must be involved in every stage of the construction process so they can evaluate the quality of representative samples of each material, piece of equipment or procedure employed in the works. The inspection or test-result reports must be delivered to the contractor in timely fashion in order to implement any necessary corrective measures.

Each inspection, trial or test must lead to a report containing general information such as date, time, and people in charge, a description of the procedure employed, relevant standards, a list of the equipment used, certificates by the body or bodies in charge of calibrating the tools and equipment used, and the results of the inspection, trial or test. The report must certify conformity with the drawings and specifications of the project and the standards chosen. In case of non-conformity with contract documents, a report must be produced detailing which aspects do not conform to the contract, including their quantity, characteristics, effects, and so on.

One of the final requirements is the production of an as-built report for every structure with an operational or investment protection objective. In the case of less demanding objectives, the as-built report may still be required contractually by the client institution. This report must include a full list of the professionals and firms that participated in the project, the studies of local and regional hazards, a list of the codes and standards applied, the final financial report, construction logs, results of trials and tests, inspection reports, component safety certificates, certificate of practical completion and final certificate, and as-built structural and architectural drawings, as

well as the plans regarding furnishings, equipment, mechanical and electrical systems, clinical gases, pipes and ducts, fire-extinguishing network, etc.

A maintenance manual for the facilities in normal conditions, and an emergency plan in the event of a disaster, must also be part of the quality assurance program.

Finally, the criteria for possession and completion of the works must be stated explicitly, such as dates, certification of conformity with the specifications and standards that governed the project, an approved as-built report, certificates that the equipment and systems have met all necessary tests, liquidated damages and cancellation of bonds posted, acceptance of the works by the relevant fiscal bodies, signed minutes of final possession of works by the client institution, and any other requirements stipulated in the contract documents.

*Annex 6.2* summarizes the minimum characteristics of a quality assurance program for the construction stage.

## References

Applied Technology Council, *ATC 51: U.S.-Italy Collaborative Recommendations for Improving the Seismic Safety of Hospitals in Italy*, California, 2000.

Building Officials Code Administrators International, *International Building Code 2000*.

Building Seismic Safety Council (BSSC), *FEMA 368: NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures*, Washington, D.C., 2001.

Building Seismic Safety Council (BSSC), *FEMA 369: NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures, Commentary*, Washington, D.C., 2001.

Chung, H. W., *Understanding Quality Assurance in Construction*, London, 1999.

Department of The Army, *ER 5-1-11: U.S. Army Corps of Engineers Business Process, Management, Regulation*, Washington, D.C., August 2001.

Departments of The Army, The Navy and The Air Force, *NAVY NAVFAC P-355.1: Seismic Design Guidelines for Essential Buildings*, Technical Manual, Washington, D.C., December 1986.

Departments of The Army, The Navy and The Air Force, *NAVY NAVFAC P-355.2: Seismic Design Guidelines for Upgrading Existing Buildings*, Technical Manual, Washington, D.C., September 1988.

- European Committee for Standardization, *Eurocode 8: Design of Structures for Earthquake Resistance. Part 1: General Rules, Seismic Actions and Rules for Buildings*, Brussels, 1998.
- Federal Emergency Management Agency, *FEMA 310: Handbook for the Seismic valuation of Existing Buildings*, Washington, D.C., 1998.
- Federal Emergency Management Agency, *FEMA 356: Prestandard and Commentary for the Seismic Rehabilitation of Buildings*, Washington, D.C., November 2000.
- Federal Emergency Management Agency, *FEMA 74: Reducing the Risk of Nonstructural Earthquake Damage, A Practical Guide*, Washington, D.C., September 1994.
- International Standard Organization, *ISO 12491:1997: Statistical methods for quality control of building materials and components*.
- International Standard Organization, *ISO 13485:1996: Quality systems, Medical devices, Particular requirements for the application of ISO 9001*.
- International Standard Organization, *ISO 13488:1996: Quality systems, Medical devices, Particular Requirements for the Application of ISO 9002*.
- International Standard Organization, *ISO 9000:2000: Quality management systems, Fundamentals and vocabulary*.
- International Standard Organization, *ISO 9001:2000: Quality management systems, Requirements*
- International Standard Organization, *ISO 9002:1994: Quality systems, Model for quality assurance in production, installation and servicing*.
- International Standard Organization, *ISO 9003:1994: Quality systems, Model for quality assurance in final inspection and test*.
- International Standard Organization, *ISO 9004:1994: Quality management and quality system elements*.
- Office of Statewide Health Planning and Development (OSHPD), *Building Standard Administrative Code, Part 1, Title 24, C.C.R*, December 2001.
- Patrucco, H., McGavin, G., *Survey of Non Structural Damage to Healthcare Facilities in the January 17, 1994 Northridge Earthquake*.
- Sistema Nacional de Protección Civil, Centro Nacional de Prevención de Desastres (CENAPRED), *Calidad en Diseño, Construcción y Supervisión de Obras: Comparación de la Práctica en México, Japón y EUA*, Memoria del Taller, 23 – 27 de Agosto, México, 1993.

U.S. Army Corps of Engineers, Engineering Division, Directorate of Military Programs, *TI 809-4: Seismic Design for Buildings*, Technical Instructions, Washington, D.C., December 1998.

## Annex 6.I Summary of the quality assurance program (QAP) during the construction stage

The following table lists some of the tasks that can be carried out in order to ensure the correct execution of the project during its preliminary stages, hazard assessments, and the design of the project.

<b>Project definition</b>
Definition of the objectives and scope of the project
<b>Definition of the work team</b> ( <i>Chapter 5</i> ) <sup>1</sup>
The client institution
The execution team
The oversight team
<b>Assignment of functions and responsibilities and limits thereof</b> <sup>1</sup>
Of the client institution
Of the execution team
Of the evaluating team
<b>Definition of the Work Program</b>
Procedures for evaluating the professional teams
Completion schedules for preliminary risk assessments and other studies, and for designing the facility
Overall budget for the assessments, design, and construction of the facility
<b>Definition of communication channels and protocols</b>
Between the specialists on the execution team and the institution
Between the specialists on the execution team and the oversight team
Among the specialists on the execution team
Schedule of coordination meetings among specialists and between specialists and the institution
Deadlines for the delivery and update of plans and specifications <sup>2</sup>

Continued  
→

<b>Definition of oversight of site selection process</b>
Review of contemplated performance objectives
Review of general background (restrictions due to economic, socio-political, technical restraints; nature of existing healthcare network; population demand for treatment, etc.)
Review of the size and impact of identified hazards
Review of feasibility of protecting structure
Review of considerations for selection of the site
<b>Definition of review, follow-up, and control mechanisms during the project phase</b>
Reviews by the oversight team
Reviews by internal teams of specialists <sup>3</sup>
Reviews across disciplines <sup>4</sup>
Reviews by outside professionals
<b>Definition of review mechanisms for the final project<sup>5</sup></b>
General review regarding the fulfillment of design criteria
Review of financial reports
Review of site plans
Review of architectural plans
Plans of the various sections of the facility
Floor plans
Section and elevation plans
Architectural detailing and finishing plans
Other architectural components (doors, windows, stairs, appendages, signs, etc.)
Review of structural plans
Review of layout plans for basic facilities, lifelines, clinical gases, A/C ducts, electrical wiring, etc.
Review of installation plans for equipment, furnishings and other components
Review of plans for details, connections and anchoring of components
Review of other plans
Review of tender documents
Review of technical specifications
Review of equipment installation specifications
Review of construction and procedures manual
Review of general contract conditions
Review of units of measures, quantities of materials and so on, completion schedule, construction budget and forms of payment
Review of other tender documents
<b>Definition of inspection procedures during the construction process</b>
Listing of construction procedures that require inspection or specialized inspection, and type of inspection required
Listing of components and services that require inspection or specialized inspection, and type of inspection required
Characteristics of the expected reports ( <i>see annex 6.3</i> )

- Notes: 1 The selection of the participating design professionals, as well as the assignment of responsibilities, must be carried out with special care. Conflicts of interest will compromise the quality of the project.
- 2 The work by each discipline must be based on the most up-to-date information issued by the other disciplines.
- 3 Each plan, technical specification, or tender document must be checked by at least one expert from a discipline other than that of the expert who produced it.
- 4 Multidisciplinary projects need to be checked at each stage by all the disciplines involved.
- 5 Before the final plans are issued, they must be submitted to the other disciplines for review and commentary.

## Annex 6.2 Summary of requirements for the quality assurance program (QAP) during the construction stage

<b>Conditions for initiating the construction</b>
Final drawings approved
Technical specifications approved
Tender documents approved by the parties
Contract signed
<b>Responsibilities of the client institution and administrative and design review teams</b>
Present the builder with a feasible project
Provide the necessary financing
Provide an adequate site
Choose the most suitable technical inspection team(s)
Participate in the decision-making process in matters critical to the project or unregulated issues
Inform participating specialists and the contractor of any modifications to the project
Keep abreast of the progress and state of the construction
Meet any other responsibilities stipulated in the contract
<b>Design team's functions during the construction stage</b>
Inform the client institution and review team in timely fashion of any changes to the original project
Assist the technical inspection team(s) in protection matters
Participate in decision-making concerning matters critical to the project or unregulated issues that require attention
Evaluate protection options presented by the contractor to the technical inspection team(s)
Carry out on-site specialized inspections
Issue certificates of satisfactory completion of the works
<b>Definition of consultancy firms</b>
Review background of firm
General information (name, address, legal representative, etc.)
Titles and specialties of the firm
Directors and professionals at the firm
Financial situation of firm
Square meters built
Certified experience of the firm (works and services)

Continued  
→

Review background of professionals or firm's qualified personnel
Name of project, chief of project, and project budget
Area constructed and project total
Area of professional expertise (chief of project, specialist, designer, assistance, etc.)
Professional activities completed (only certified activities)
Field of specialty
Standards and regulations applied in other projects
Evaluate feasibility of achieving project objectives
<b>Definition of the builder's main functions and responsibilities</b>
Manage the administrative and legal aspects of the intended construction
Review upon receipt the architectural, structural, equipment, and detail plans
Review upon receipt all technical specifications
Ensure that the construction meets all the plan and specification requirements
Ask suppliers to provide all safety certificates required
Supervise the pace at which the construction advances
Control all resources used in the construction of the project
Carry out any tests needed to ensure the quality of the project
Produce reports on the progress of the construction
Establish program of payments to suppliers and subcontractors
Keep a builder's log
Be fully aware of the details and objectives of the project
Acquire materials, hire labor, and arrange subcontracts of a quality befitting the requirements of the project
Assume responsibility for the actions of all subcontractors
Assume responsibility for the construction methods and sequences employed
Update the builder's log in timely fashion
Respond in timely fashion to requests for information by the client institution and coordination team, technical inspection team, specialists, and external inspectors
Provide access to external inspections, inspections by the project administrator, by the technical inspection team and the other disciplines in charge of the design of the project <sup>1</sup>
Inform the technical inspection team of any modification, voluntary or involuntary, to the original project
Assume responsibility for on-site safety during the construction process
Carry out any other tasks called for in the contract

Continued  
→

<b>Technical inspection team's functions</b>
Maintain ongoing control of the construction program
Review construction procedures
Regularly engage in inspections regarding the quality of the construction materials used
Verify the quality of the labor employed
Assist the contractor in specific technical matters
Supervise the work of the external inspectors
Verify compliance with project specifications
Participate in the decision-making process in matters critical to the project or unregulated issues
Act as permanent liaison between the contractor and the institution, the project administrator, and the coordination committee
Continually check the builder's log
Safeguard and control contract documents
Verify the application of correct safety measures during the construction process
Develop inspection and testing program <sup>2,3</sup>
Inspect the materials, teams and procedures used for the project continually and effectively <sup>4</sup>
Obtain representative samples for the materials used in line with the methods and materials employed in the construction
Distribute builder's and technical inspectors reports in a timely manner ( <i>see annex 6.3</i> )
Carry out any other contractual obligations
<b>Definition of channels and protocols of communication for conveying test results</b>
From the inspection team to the contractor
From the contractor to the inspection team
From the technical inspection team to the design team and the client institution
<b>As-built report on the facility<sup>5</sup></b>
Listing of professionals and specialists that participated in the project
Reports of geological and soil mechanic studies of the chosen site
Reports on regional and local risks (if applicable)
Definitive financial reports
Builder's log and related documents
Inspection reports
Test results
Safety certificates for the components and certification of correct construction practices
Listing of codes and standards applied
As-built plans of architectural components and furnishings
As-built plans of the structural system
As-built plans of the mechanical and electrical systems and equipment
As-built plans of basic facilities, clinical gases, ducts, A/C, fire extinguishing network, etc.
Other as-built information as defined by the institution and the coordination committee

Continued  
→

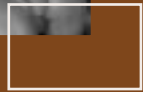
<b>Definition of criteria for acceptance of the works</b>
Effective conclusion of the works as stipulated in the contract
Compliance with the specifications of the project
Certification of fulfillment of security requirements
Approval of as-built report
Satisfactory implementation of tests on the operation of services, systems and equipment
Fines paid
Return of deposits
Approval of the construction by financing agencies
Delivery of the construction to the institution
Signed minutes of final receipt of the works
Other criteria stipulated in the contract

- Notas:
1. The client institution or the specialists that participated in the design stage may demand that the contractor stop the works if the safety requirements and quality standards stipulated in the project documents are not being met.
  2. All equipment and tools used in the inspections, trials or tests must have certificates of calibration issued by a recognized institution.
  3. The entity in charge of the trials and tests must have permanent access to the construction site.
  4. The entity in charge of the trials and tests may reject the use of particular materials and equipment.
  5. An as-built report must be produced for any building with a functional or infrastructure protection objective. For buildings with a life-safety performance objective, the as-built report must be produced if it is expressly requested by the client institution or coordinating team.

## Annex 6.3

### Characteristics of inspection reports

<b>Report on inspection or test</b>
General information (date, hour, etc.)
Staff in charge of the inspection or test
Procedures employed during inspection or test
List of equipment used during the inspection or test
Certificate from entity in charge of calibrating the equipment and tools used in the inspection process
Results of the inspection or test
Characteristics of the materials inspected or tested
Characteristics of construction processes inspected
Results of the tests of materials or tests of correct operation
Inspected activities carried out or completed in compliance with project plans and specifications
Aspects in which there is no compliance with the project plans, specifications, standards and/or codes
<b>Report of non-compliance</b>
Description of the non-compliant feature (including text and/or sketch specifying how feature does not comply with the plans, etc.).
Location of the non-compliant feature
Qualitative description of the non-compliant feature
Other characteristics of the non-compliant feature
Actions needed to correct non-compliance
Processes that must be modified in order to prevent the recurrence of non-compliance



# Appendix

## Terms of Reference for Vulnerability Reduction in the Design of New Health Facilities

The following text is included for illustrative purposes only. Its aim is to provide suggestions for reducing the vulnerability of health facilities through the inclusion of the provisions recommended in this handbook in the traditional Terms of Reference for the design of a hospital or other kind of health facility. Underlined sections or phrases should be adjusted to the specific hazards faced by the project.

### 1. General terms

- 1.1 The present Terms of Reference are an integral part of the call to tender for the design of \_\_\_\_\_ Hospital, and state the additional requirements that must be met in the design of the facility’s protection systems to ensure that they meet the protection objectives defined for the facility in both normal and emergency conditions. The protection objectives are in *Table A.1*.
- 1.2 These provisions set minimum requirements only. Each consultant, specialist or supplier must establish and identify additional conditions that its design or product must meet in order to satisfy the protection objectives set by the institution.
- 1.3 Quality assurance principles and means applied in this project will be recorded in a single document. No tacit agreements or implicit demands will be tolerated.

### 2. Definition of protection objectives

- 2.1 The facility and its services must withstand the following hazards: landslides, mudslides, strong winds and hurricanes, floods, earthquakes, and volcanic activity, as well as any others that may be identified in the course of the project. For each hazard, two or more levels of intensity are specified. For each hazard and level of intensity, the institution has defined performance objectives for the intended services as stipulated in *Table A.1*.

**Table A.1 Performance objectives based on varying intensity of hazards**

Event	Minimum level recommended			Maximum credible level desired		
	%/Years	Time for rehabilitation	Protection objective (LS/IP/OP)	%/Years	Time for rehabilitation	Protection objective (LS/IP/OP)
Landslide						
Mudslide						
Flood						
Earthquake						
Strong winds						
Volcanic activity						
Other						

2.2 The standby capacity (i.e., the capacity to remain isolated from critical utilities and services external to the hospital) is specified in *Table A.2*.

**Table A.2 Facility’s standby capacity**

Service	Standby capacity
Drinking water	# hours
Electricity	# hours
Oxygen	# days
Oil	# days
Other	# days/# hours

2.3 The stipulated times for recovery of functional capacity in the case of each service are presented in *Tables A.1* and *A.2*.

2.4 The hazard characterization documents, design procedures specific to each one of the hazards, and geotechnical properties of the proposed site, as specified below, are an integral part of this tender. (All relevant tender documents should be listed here).

### 3. General design of the hospital

3.1 The design procedures must meet ISO9000 quality standards.

3.2 The head of each team of design specialists must have at least 10 years’ experience in hospital infrastructure design that is relevant to the job he or she must perform. In addition,

his or her participation must be documented and certified in the design of hospitals with a total built surface greater than 100,000 m<sup>2</sup>, and at least one hospital built with a surface larger than 10,000 m<sup>2</sup> in the same period.

- 3.3 Candidates to the various professional teams must present documents that certify their participation in the design of hospitals that have met investment-protection and functional-protection standards.
- 3.4 The documents produced during the design stage, including specific protection considerations, must include the following:
  - Financial reports
  - Certificates that the performance objectives defined by the institution have been met
  - Mockups
  - Siting plans
  - Architectural drawings such as general distribution plans, floor plans, section and elevation plans, architectural detailing plans and any other relevant plans
  - Structural plans, including general specification plans, foundation plans (based on the information provided by the soil mechanics specialists), floor, section and elevation plans, structural detailing plans, etc.
  - Drawings showing the layout of basic facilities, lifelines, clinical gases, air conditioning, electrical distribution, etc.
  - Industrial, mechanical, and electrical equipment floor plans
  - Furniture floor plans
  - Technical specifications
  - Specifications on proper installation of the equipment
  - Construction and maintenance manual
  - General conditions contained in the contract
  - Work program, including units of measure, quantities of materials and labor, completion schedule, and forms of payment, inter alia
  - Terms of reference and other tender documents
  - Maintenance manual and emergency plan for the facility

- 3.5 The documents listed above shall be written clearly and explicitly to prevent errors of interpretation.
- 3.6 The systems used for component protection shall be feasible to build and amenable to effective maintenance.
- 3.7 Each team of specialists shall prepare a document setting out clearly how it will meet the facility's performance objectives and, particularly, what their requirements and restrictions are in relation to the other disciplines. Such documents must define, moreover, the criteria for hazard analysis and design, and the standards and codes employed. They must be produced at the beginning of the project, and approved by the client institution.
- 3.8 The project administrator and the client institution's project coordination committee will supervise the correct integration of the participating teams, including those involved in structural, architectural, and installation matters. In order to do this, they shall coordinate all the specialist teams. The teams will obtain from the project administrator and coordination committee drawings and specifications setting out in detail the layout of all systems, equipment and components of the facility, including those that do not belong to their specialty. These drawings will superimpose the subprojects developed by all the disciplines and specify the layout and the points at which installations will meet, as well as the location of the various components, such as suspended ceilings, lighting fixtures, electrical and other outlets, sanitary devices, HVAC devices, built-in furnishings, industrial equipment, medical equipment, and fire safety systems. Likewise, they will specify the layout of all the wiring, piping and ducts and their passage through walls, beams, foundations, columns, etc. These plans must be studied in detail by the coordination committee and the specialist teams in order to ensure that the protection systems will work in integrated fashion.
- 3.9 Before the final plans are issued, drafts must be delivered to the other disciplines for review and commentary.

## **4. The design of the structure**

- 4.1 The structural system chosen for the facility must meet the performance objectives set both for the hospital as a whole and its component services.
- 4.2 The team of structural engineers will be in charge of guaranteeing the safety of the structure. When the protection objective of the facility and its services is functional and investment protection, the team must provide a structural system that not only safeguards the structure but also the nonstructural elements. In other words, the structure must not only protect itself and its occupants but also the nonstructural systems on which investment or functional protection are to be based. For this reason, the structural system needs to be explicitly approved by all participating disciplines.

- 4.3 The structural team must coordinate its design decisions with the architectural and other design teams (sanitary, air conditioning, electrical, etc.) so as to meet their protection requirements, including such matters as drilling, bracing, or anchoring.
- 4.4 The structural system and its components must be designed to withstand permanent and eventual demands on the structure, taking into account its dead load, live load, seismic and wind loads, snow and ash loads, temperature changes, hydrostatic and hydrodynamic thrust forces, total and relative foundation settlement, etc.
- 4.5 Structural design shall incorporate such detailing as will ensure, for each level of risk, that the performance objective will be met. It is important to include in the design any systems needed for guaranteeing that, in the event of damage or functional loss, services can be restored within a predefined period.
- 4.6 The structural team must provide the information required by the other disciplines for the design of the equipment, systems, and other nonstructural components.
- 4.7 The structural team must certify that the protection objective set by the institution for the facility has been met.

## 5. Design of nonstructural components

- 5.1 Nonstructural components must enjoy a level of protection commensurate with the performance objectives set for the medical or support services to which they belong or with which they are directly or indirectly linked in functional terms.
- 5.2 Each team shall be responsible for the design of the protection systems for the components of their competence, and shall certify that the protection objective set by the institution has been met.
- 5.3 All nonstructural components to be protected must be adequately supported. The points of support of these components must enjoy a level of safety comparable to that of the components themselves.
- 5.4 In cases where nonstructural components exert pressures or lean on other nonstructural components, their joint stability must be guaranteed.
- 5.5 Safety of any equipment containing hazardous materials must be tested and certified.
- 5.6 Safety of nonstructural components must be assessed, either by mathematical analysis and modeling, or by certification of safety by the supplier or manufacturer.
- 5.7 If a safety assessment of nonstructural systems, equipment, and components is to be carried out through mathematical analysis and modeling by the relevant team of specialists, the team shall present a financial report recording, at a minimum, the following: The type

of system, equipment or component contemplated; a description of the component; the performance objective considered in the design of the protection systems in question; the standards applied in the analysis; a description of the structure in which the component is to be embedded; any behavior that may determine the response of the component; characteristics of the component when in operation; characteristics of the component's bracing, anchoring and support systems; the method of analysis; the likely load; the results obtained, and an assessment of the component's interaction with other systems, equipment or components.

- 5.8 If the safety assessment of standard nonstructural systems, equipment, and components is based on the supplier or manufacturer's certification through in-house analysis, that supplier or manufacturer must present a calculation log with the same contents described in provision 5.7.
- 5.9 If the safety assessment of standard nonstructural systems, equipment, and components is based on the supplier or manufacturer's certification through experimental means, the supplier or manufacturer must present a document with the following information: identification of the laboratory, standards of reference considered in the tests, description of the testing procedures, and test results.
- 5.10 In addition to the certificates described in provisions 5.7, 5.8 and 5.9, the following information should also be provided: Requirements for meeting the certification conditions (conditions of use, operation, installation, etc.); date of certification and period of validity of the certification; certification of compliance with the standards specified in the contract; and description of the applicability and limitations of the certificates.

## Glossary

### Definition of Basic Concepts

<b>As-build report</b>	Set of documents concerning project management, such as the contract, a list of the professionals involved in regional and local risk assessments and their qualifications and reports, the design of the project, construction and inspection procedures applied, applicable codes and standards, certificates of component safety, final plans for the structure, its components and protection systems, and certificates of compliance with project specifications.
<b>Critical services</b>	Services that are life-saving, involve hazardous or harmful equipment or materials, or whose failure may generate chaos and confusion among patients or staff.
<b>Natural hazard</b>	A likely event of natural origin and sufficient intensity to cause damage in a particular place at a particular time.
<b>Nonstructural components</b>	Elements that are not part of the load-bearing system of the building. They include architectural elements and the equipment and systems needed for operating the facility. Among the most important nonstructural components: architectural elements such as façades, interior partitions, roofing structures, and appendages. Nonstructural systems and components include lifelines; industrial, medical and laboratory equipment; furnishings; electrical distribution systems; HVAC systems; and elevator/escalator systems.
<b>Nonstructural detailing</b>	A set of measures, based on the theoretical, empirical, and experimental experience of the various disciplines, aimed at protecting and improving the performance of nonstructural components.
<b>Protection systems</b>	Devices and procedures aimed at providing safety to the structural and nonstructural components of the facility and meeting its performance objectives.
<b>Quality assurance</b>	A set of actions aimed at ensuring that project performance objectives are met.
<b>Resistant system</b>	A structural system especially designed to withstand the impact of gravity and other natural phenomena. The structural system must be designed in such a way that its detailing is proportional to the protective objective chosen for the structure.

Continúa  
→

<b>Risk</b>	Extent of the likely losses in the event of a natural disaster. The level of risk is intimately associated with the level of protection incorporated into the structure.
<b>Specialized inspection</b>	A set of activities aimed at ensuring that the requirements of the project are met in matters such as quality of the work, the use of construction processes and materials commensurate with the performance objectives of the project, the fulfillment of the provisions established in the standards and codes referenced in the contracts, and the procurement of component safety certificates and others.
<b>Structural components</b>	Elements that are part of the resistant system of the structure, such as columns, beams, walls, foundations, and slabs.
<b>Structural detailing</b>	A set of measures, based on the theoretical, empirical and experimental experience of the various participating disciplines, for protecting and improving the structural component performance.
<b>Tender documents</b>	Legal documents that stipulate the characteristics of the design or building contract or contracts (parties involved, financial amounts, deadlines, forms of payment, etc.) and the technical characteristics of the construction (general and detail plans, structural and nonstructural components, standards and codes to be followed, specialized inspection requirements, recommended and unacceptable construction methods, etc.).
<b>Vulnerability</b>	The likelihood of a facility enjoying a particular level of protection suffering physical damage or being affected in its operations when exposed to the impact of a natural hazard.