

**PROCEDURE FOR STRUCTURAL APPRAISAL, REPAIR
AND RETROFITTING OF CONCRETE STRUCTURES**

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**Procedure for Structural Appraisal, Repair and
Retrofitting of Concrete Structures**



By

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Judul: THE PROCEDURE FOR STRUCTURAL APPRAISAL,
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ABSTRACT

In recent years, the importance of maintaining all existing concrete structures has increased. As all existing concrete structures are exposed to a range of hazards, it is inevitable that concrete structures have deteriorated caused by environment effects and fatigue. Therefore, the procedure for maintenance of concrete structures involving several stages which are the structural appraisal, repair and retrofitting of concrete structures shall be carried out. The structural appraisal shall check the adequacy of an existing concrete structure. Preliminary investigation and detailed investigation are necessary to check the strength and serviceability of the concrete structure. When concrete structure is found inadequate in service, repair and retrofitting works must be carried out. Methods of repair and retrofitting must be selected to rectify the structural problems by considering mainly the cost estimation and the effects to the adjacent structures during ongoing operations. In short, this report aims at providing a guideline in the procedure for the maintenance of existing concrete structures particularly in Sarawak in order to maintain safe concrete structures for its intended use.

The procedure of maintenance of a concrete structure involves several stages, which are, in their proper order, the appraisal, repair and retrofitting.

Structural appraisal is a different activity to structural design. Appraisal stages involve preliminary investigations, documentation, field observations, condition survey, sampling and material testing on the structure. These will be discussed further in this report. Uncertainties present at the design stage are absent. The information obtained includes the actual condition and the variability of the structure as oppose to what the designer assumed.

Structural appraisal aims to check the adequacy of an existing structure for reasons of (ISE,1996) :-

- 1) purchase, insurance or legal purposes
- 2) change of time
- 3) defects in design and construction
- 4) deterioration with time or in service
- 5) accidental, fire or other damage
- 6) assuring safety and/or serviceability for future use
- 7) structural alterations
- 8) change of environmental conditions

Structural adequacy can be examined under overall stability, strength, robustness, geometric permanence, stiffness, dynamic response, fire resistance, durability, impermeability and appearance of the structure (ACI,1997).

Repair involves replace or correct deteriorated, damaged or faulty structure (ACI 1997) whereas retrofitting is to restore the structures to its condition where the intended use of the structure is served. Whenever a structure is found inadequate, repair and retrofitting of the existing concrete structure should be carried out. Methods for repair and retrofitting is identified to regain structural safety and serviceability at economical cost.

1.2 Objective

This report is presented to provide a guideline in the procedure for the maintenance of concrete structures in order to maintain safe concrete structures for its intended purpose.

CHAPTER 2

PRELIMINARY INVESTIGATION

2.1 Introduction

Basically, structural appraisal consists of two major stages which are the preliminary investigation and detailed investigation. It leads to a series of assessments of the strength and future serviceability of the structure (ISE,1997). For each stage, information is collected and assessed and if the result of the assessment shows that the structure is adequate, no rehabilitation is needed. If the result is inconclusive, more information can be collected and rehabilitation needs to be carried out. After having the results of the preliminary investigation, the detailed investigation must be carried out.

2.2 Scope and Methodology

Preliminary investigation provides initial information regarding the condition of the structure, the type and seriousness of the problems affecting it, the feasibility of performing the intended method of repair and retrofitting and information on the need for a detailed investigation (ACI,1997). In other words, preliminary investigation is typically introductory in nature and is not comprehensive. It commonly identifies the need for a more detailed and extensive study and for an additional scope of services. In some cases, the preliminary investigation may determine that it is not desirable to proceed with detailed investigation as structure has excessive damage where its integrity cannot be economically restored.

The scope and methodology of a preliminary investigation depends on the size and complexity of the project. It involves the following steps (ACI,1997) :-

A) Review of plans, specifications and construction records

The first step is to collect available plans, specifications and construction records. This information is gathered from documents, the site survey and oral accounts. Construction records consist of field inspection records, contractor and subcontractor diaries, survey notes and job progress reports. For older structure, the process can be tedious and consume far more time than the actual review.

The original designers and original contractors are generally the best sources to search for documents and records. When original documents are not available, nondestructive testing and physical measurements can be used to supplement visual observations.

B) Site observations of conditions

Site observation record sheets shall be developed for recording information obtained during the site investigation. It should provide essential information on structural features such as beam, column and dimensions. A list of items or question obtained during the records review concerning as-built status, alteration or possible changes in structure use since its original construction should be also developed and checked in the site. Assessments of the conditions observed and specifically the need for follow-up and appropriate remedial actions should be recorded. Photographic records or videotapes are valuable aids in classifying and communicating information on the conditions and problems observed in the site. Condition rating for members of structures is required to compare the present condition of the member when the member was new. The rating is generally categorized as Good, Fair, Poor and Critical (Kenneth R. W.,1992).

C) *Structural measurements*

The site condition survey requires measurements of member dimensions, length and deflections magnitude. Any displacements, cracks and other damages of a structural should also be noted. Additional measurements are needed when alterations to a structure have been made without proper documentation. Measurements can be carried out by installation of instrumentation system such as electronic, mechanical devices and conventional surveying equipment.

D) *Nondestructive testing*

Preliminary nondestructive testing helps to identify locations within a structure where more comprehensive nondestructive and destructive testing may be required. The most common techniques used during preliminary investigations such as acoustic impact (sounding and chain dragging), magnetic detection instrument (cover meters), rebound hammer, penetration resistance and forced vibration tests.

E) *Exploratory removal*

Exploratory removals are considered exception during the preliminary investigation. It helps to determine existing features and to gain reliable information about the nature and extent of existing problems in the structure. Selected exploratory removal is used when structure is found to have substantial evidence of serious deterioration or distress when hidden defects is suspected in the structure.

F) *Sampling, testing and analysis*

Sampling and testing are not usually performed during the preliminary investigation. Samples are only needed for testing when there is a lack of information on the nature and properties of the materials in the structure, deterioration of materials is suspected in the structure and the requirement to assess for the future life of the structure. Materials are analyzed to assess the quality and mechanical properties of the concrete and reinforcement in a structure.

2.3 Results

The preliminary investigation is generally involving two primary scope which are the review of existing records on the structures and the condition survey of the structures. The information obtained from the preliminary investigation must be gathered for evaluation of structural concrete.

From the information gathered, the results that can be obtained from preliminary investigations are generally :-

Structural capacity check

Structural capacity check are categorized as the structure is adequate for the intended use, the structure is adequate for the existing loads but may not be adequate for intended use and the analysis may be inconclusive

Project feasibility

When the proposed repair and retrofitting method is required, project feasibility should consider the expected effectiveness of the rehabilitation, its estimated life-cycle cost, the effects of the rehabilitation on the structures and the impact on the operation of the structure.

Identification of structural problems

When structural problems are identified, steps must be taken to verify the problems and to determine whether the structures need remedy works or protection of existing structures. The structures should be described in terms of their seriousness and extent. Immediate action to deal with a condition affecting the safety or stability of the structure is necessary.

Strengthening requirements

Strengthening the existing structures must take into consideration the operation of the structures both the current and future use. Methods of strengthening structures should be considered to satisfy the intending loading requirements.

Further investigations

The end result of a preliminary investigation is to determine that a detailed investigation is needed. The objectives of the detailed investigations must be properly defined and the additional information is required to satisfy these objectives.

2.4 Detailed Investigation

It is important that before proceeding with the detailed investigation, the preliminary investigation must be completed, the owner's goals are identified to be feasible, the objectives of the detailed investigation is well defined and the project budgets and costs of the detailed investigation should be approved by the owner.

Detailed investigation generally consists of (ACI,1997):-

- Documentation
- Site observations
- Sampling and material testing
- Evaluation

CHAPTER 3

DOCUMENTATION

3.1 Introduction

The first major task in the detailed investigation studies is documentation. Documentation should be reviewed to minimize the assumptions necessary to check for the structural adequacy. Available documentation will save both time and cost associated with appropriate repair and retrofitting methods. All sources of existing information concerning the design, construction and service life of the structure shall be collected to learn more about the structure. Four major information which need to be reviewed involves design, material, construction and service history information.

3.2 Design Information

Design information shall include documentation of useful structural information and historic structures information. This information is pertinent to define the functional requirements and expected loading for components and structures. The assembly of design information can be time-consuming but it is very important to examine the structural adequacy.

Design drawings, specifications, shop drawing, as-built drawing and alteration plans are some of the useful structural information which need to be gathered. Information regarding original construction or alteration plans assembled from the owner, architect or engineer, general contractor and subcontractors may be valuable.

When details of a particular structure from the structural information are lacking, documents may be available from those organisations involved in the design and construction works provided that the structure is designated as historic structures. For example, substantial information regarding reinforced concrete design on many older structural designs can be obtained. This is because many reinforcement systems were protected and were illustrated in catalogs during the planning for the preservation of historic structures.

3.3 Material Information

Relevant documentation on material information should be made available to develop an understanding of the type of materials that were originally specified and used. The information includes the reports on the proportions, properties and test results of the concrete mixtures and mill test reports on cement and steel reinforcement. The material specifications and drawings including all the placing drawing prepared by material suppliers and used to place their products in the original construction shall be collected.

3.4 Construction Information

Construction information includes construction methods, construction materials and the problems encountered during construction work. If available, this information will determine the feasibility of repair and retrofitting process. Information concerning the foundation and soil bearing capacity, allowable soil bearing pressures used in the design, soil and foundation work, including backfill and compaction, pile driving records and pile cap modification drawings must be obtained. When foundation loadings are to be increased or foundation settlements have been noted, information of soils and foundation records can be useful.

Construction information should also include diaries kept by the construction team, results of test on fresh and hardened concrete, quality control data, field inspection reports, as-built drawings, drawing and specifications kept on the job, job progress reports and photographs, survey notes and records; and correspondence records of the design team, the owner, the general contractor, subcontractor, material suppliers and fabricators

3.5 Service History

Service history includes all documents that define the history of the structure from the original construction to the present condition. It should be reviewed to get to know more about any distress, damage and deterioration to the structure.

The information relates to service history of structure can be summarized as information on operation, overloading and load limits, insurance reports and records of damage by fire, wind or overloads, weather records, records of current and former owners of the structure and photographs. Other source concerning the design and construction of a structure is the personnel involved in the processes. The information can be valuable if they can reveal the problems encountered during the design and construction of the structure. Interviews with these personnel often to gain useful information.