INTERVENTION METHODOLOGY
TECHNICAL TEAM

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CRITERIA FOR INTERVENTION

Sub-chapters:
1. Introduction
2. Forms of intervention
3. Intervention strategy
4. Procedure of analysis
5. Chapter conclusions
1. Introduction
1. Introduction

An intervention methodology must define the set of type procedures to implement before any action and support the decision making. Should include complementary analysis in situations where potential serious structural deficiencies are detected.

Before intervening in a given building, several aspects should be analyzed: service life of the construction, durability, types of anomalies, associated causes and effects, tests (in-situ and laboratory), monitoring of anomalies, inspections systems and types.
Constraints to rehabilitation interventions:

The final decision will be conditioned, in one hand, by the desired range with the operations to be carried out, by the type of construction involved, by the existing technical conditions, by the total estimated cost in view of the desired capital appreciation and by other factors of technical-economic, social and political nature.
1. Introduction

Constraints to rehabilitation interventions:

- historical-cultural context, in which the building is placed and the corresponding patrimonial/architectural value;
- occupation and past usage and their coordination with the future operation of the building;
- materials used in rehabilitation operations (compatibility and performance maintenance).

Ancient stone and brick masonry
2. Forms of intervention
2. Forms of intervention

Forms of intervention:

- immediate demolition / replacement - the element / construction represents a risk to users and its rehabilitation is not economically viable; demolition / replacement can be partial or total;

Damage resulting from seismic activity. Demolition if rehabilitation is not economically viable. Wooden pavement.
2. Forms of intervention

Forms of intervention (cont.):

• “let it be” - in the face of the current state of the element / construction, intended use and useful service time planned, no action is defined; the deterioration process follows its normal rhythm;

• “wait and see” - are not gathered sufficient data to make an informed decision; in this case, it is expected the development of events or more data is collected (tests);
2. Forms of intervention

Forms of intervention (cont.):

• repair - restore the original, physical and structural properties of the element or the construction (for correction execution errors, as opposed to natural phenomena - earthquakes, fires, natural wear, among others.);

• strengthening - increased stiffness, ductility or initial resistance capacity of building by changing its geometrical and / or mechanical characteristics, caused by a different use from that for which it was designed (increased load), need to change the initial structure, among others;

Facade with renders in an advanced state of degradation
2. Forms of intervention

Forms of intervention (cont.):

• consolidation - a means of improving normal in-service performance of an existing building, increasing the structure's stiffness by eliminating deformations, vibrations or excessive cracking;

• protection - an increase of barriers to aggressive agents (water control in construction, the action of the pigeons, etc.) or reduce of degradation surface conditions (painting, etc.).

Mechanism of efflorescences and crypto floroscences formation in a wall
INTERVENTION METHODOLOGY

2. Forms of intervention

What forms of intervention to consider?
The lack of some blocks of the arc led to some cracks. In this case, simply putting new units and repair the cracking to restore the initial conditions of strength.

Very significant damage due to wind action.
3. Intervention strategy
3. Intervention strategy

Whatever the form of intervention is chosen, it will have to reconcile the repair work with the existing building, using appropriate materials and equipment, skilled labour and rationalizing costs.
3. Intervention strategy

**Intervention criteria to rehabilitate a construction:**

- ensure the sufficient degree of reversibility, not compromising the ability of future intervention, added with a scientific and technological capabilities to ensure sustained conservation of materials and existing constructive solutions;

- prefer proven materials and technology solutions, at the expense of sophisticated techniques and products without conclusive assurances relating to future performance;

- document exhaustively and clearly the pre-existing reality and all the amendments made;
3. Intervention strategy

- ensure structural, constructive, fire and intrusion safety conditions;

- contribute to the improvement of building performance, spaces, equipment and facilities, not allowing in any way that architectural, functional and constructive attributes be lower than those pre-existing ones;

- promote the maximum constructive coherence, predicting the best and biggest use of elements and parts of the existing building;

- not alter or destroy cultural, historical or artistic evidence found during the intervention.
INTERVENTION METHODOLOGY

3. Intervention strategy

All rehabilitation actions should be characterized from a technical (feasibility) and economic perspectives.
4. Procedure of analysis
4. Procedure of analysis

Analysis methodology for decayed buildings:

- diagnosis of the problem and the need for intervention and emergency measures;
- constitution of the expert team;
- analysis of the design;
- analysis of the compliance of the construction work with the design;
- damage survey (non-destructive or semi-destructive testing);
- identifying the causes (diagnosis);
- structural assessment (prognosis), reanalysis, stiffness, redistribution;
- recalculation of the structure;
- retrospective analysis;

Cracking due to movements of the structure
4. Procedure of analysis

- analysis of the various possible options for intervention;
- selection of techniques / materials;
- technical-economic analysis of designed solutions to repair / strengthening;
- elaboration of the intervention design;
- execution of the rehabilitation works and quality and safety controls;
- post-implementation testing;
- monitoring of the construction future behaviour.

This methodology must be adapted to each specific case (structural or non-structural anomalies, severity of anomalies, type of construction, among others).
a) Diagnosis of the problem and the need for intervention / emergency measures:

Should be performed an inspection visit to the building by a technical team with experience and knowledge about the materials and types of construction that performs:

- direct observation carrying eventual tests / measurements;
- assessing the need for intervention and for urgent measures (evacuations, shorings, load reduction, among others).
b) Constitution of the expert team:

- depends on the size, complexity and state of degradation of the construction as well as the risk that its structure may represent to people and property in its vicinity and its possible architectural and cultural interest;

- should be restricted to trained personnel, aided by the necessary equipment for the determination of key data.
4. Procedure of analysis

c) Analysis of the design:

• the implementation design shall be subject to a thorough analysis in order to detect any errors which were the cause of the problems or who have contributed to them;

• should resort to the regulations in force at the time of its execution and not at present;

• the implementation drafts (if any) may not include subsequent changes to the building.
d) Analysis of the conformity of the work with the design:

- checking of dimensions of structural elements, new elements from previous intervention, network tracing, among others.
4. Procedure of analysis

e) Damage survey: (non-destructive or semi-destructive testing):

- data to survey - cracks, degraded areas, deformations in pavements, characteristics of the foundation soil, settlements, position / location of structural elements, corroded areas, biological attack, among others;

- visual analysis has its limitations, one of which is the fact of ignoring the history of the building load; the construction reports and any previous inspections reports, are fundamental tools when available;

- the use of in-situ testing allows to obtain additional data.
f) Identification of causes (diagnosis):

Interpretation of the observations made and data collected so that can be associated with defined causes.

The elimination of the causes of the anomalies is the most effective process to solve the anomalies.

Rot and deformations due to water leakage in roof
4. Procedure of analysis

Consider the probable causes for these anomalies

Anomalies observed in cladding and masonry
4. Procedure of analysis

INTERVENTION METHODOLOGY

Surface condensation

Water infiltration in the connection frames / facade

Rising moisture
4. Procedure of analysis

In general, to an anomaly exists more than a cause, with the anomaly being associated with the accumulation of multiple errors:

- design errors (poor design, miscalculation, poor material prescription, among others);
- execution errors (poor quality of materials, lack of technical skills, misinterpretation of the design, among others);
- service errors (lack of maintenance, modification of the use conditions (unexpected loads), change in geometry);
- occurrence of natural disasters (earthquakes, fire, explosions, shocks, floods).
4. Procedure of analysis

g) Structural assessment (prognosis), reanalysis, stiffness, redistribution:

All the subsequent operations, in relation to predominantly structural aspects, rely on knowledge and evaluation of the strength of the existing structure.

- aspects to consider: modification of the mechanical characteristics of materials, redistribution of efforts over time due to delayed effects, transmission of efforts to the less damaged parts due to release of others, modification of the dynamic characteristics of the structure, estimated useful life, among others.
4. Procedure of analysis

h) Recalculation of the structure:
Does not differ conceptually from the calculation of a new structure.

- particularities - accurate determination of dead loads, evaluation of live loads of use in light of the regulations in force and its expected lifetime, checking of the bearing capacity of the sections taking into account their actual dimensions and the actual characteristics of materials, among others.

i) Retrospective analysis:
Analysis that allows the confirmation of the accuracy of the diagnosis. It is based on the actual values of the solicitations, the materials characteristics and geometry of the existing elements.
4. Procedure of analysis

j) Analysis of several possible options for intervention:

• reject at the outset the solutions that, of their characteristics, are not of a viable application in the case in study;

• resource to several criteria: degree of difficulty of execution, security level, occupation status of the construction, execution time, economic factors, users needs, among others.
4. Procedure of analysis

In view of the degradation degree and the severity of the observed anomalies at the construction, one of the following options can be taken:

- make only cosmetic repairs, i.e., to reconstruct the external appearance of the building (enough bearing capacity);

- not to do structural repairs, although insufficiencies were found, but keep the building under observation to detect any signs of worsening state;

Interior wall coating in need of repair
4. Procedure of analysis

- carry out repairs but only to restore the original capacity of the structure, that is, reset the structure to its initial setting state with the possibility of limiting the live loads of usage;

- repair and strengthen the structure in order to increase its bearing capacity, modifying or not its structural system, temporarily vacating it or not;

- demolish the existing building or part of it by representing a potential hazard.

Wooden structure of the balcony in an advanced state of degradation
4. Procedure of analysis

What options to consider for these buildings?
4. Procedure of analysis

**INTERVENTION METHODOLOGY**

"Cosmetic" repair

Repair the coating. However, evaluate whether there are problems of rising dampness.

Repair and reinforce

Restore the original capacity through repairs (cracking due to differential settlement), possibly including the strengthening of foundations.
k) Selection of techniques / materials:

The techniques may be of structural or non-structural domain, depending on the type of anomalies found in the construction:

• techniques to repair non-structural anomalies - reset the performance characteristics (requirements) of materials / elements (non-structural) of the construction;

• techniques to repair structural anomalies - reset the characteristics of structural safety requirements, acting at the level of the resistances or the actions.
4. Procedure of analysis

k.1) Repair techniques to non-structural anomalies:

The techniques will depend on the final performance to be achieved, taking in account the existing anomalies, available means and involved costs.

Possible strategies:
- elimination of anomalies;
- replacement of affected materials and elements;
- protection against aggressive agents;
- cover-up of anomalies;
- elimination of the cause of the anomaly;
- reinforcement of behaviour on the functional requirements.

This division does not imply the application of only one solution, it is sometimes necessary to apply more than one type of intervention.
INTERVENTION METHODOLOGY

4. Procedure of analysis

k.2) Repair and reinforcement techniques to structural anomalies:

Solutions for improving safety in relation to loads of gravitational nature:

• introduction of mechanical connections;

• injection of binding mortars;

• strengthening and repair in foundation ground soil;

• strengthening of foundations.

Injection of grout
k.2) Repair and reinforcement techniques to structural anomalies:

Solutions for behaviour improving regarding seismic actions:

• replacement of defective materials;

• alteration of the efforts distribution;

• overall increase in stiffness and strength by adding of new structural elements and / or the substitution of other.
4. Procedure of analysis

I) Technical-economic analysis of solutions designed to repair and reinforce:

Choose of the constructive process to be used:
• criteria - cost, capital gain resulting from the intervention, among others.

Decision making:
• necessary knowledge of the available techniques;
• available materials;
• qualification of manpower.

Consolidation technique of walls
m) Elaboration of the intervention project:

- careful specification of the materials to be used;
- methodology to be followed;
- conditions of use;
- needs for maintenance and inspection.

Schematic studies of introducing new structural elements
n) Execution of works and quality and safety controls:

Preliminary and preparatory work:
• define the work to be performed before each intervention: surface preparation, cleaning actions, eliminate contact with damp areas, eliminate large deformations, eliminating the progression of fungi and insects, fire protection, security measures, among others.

Quality control:
• certification of materials for rehabilitation and strengthening (credible products; calculated, detailed and executed with application procedures and packaging procedures; storage and transportation);
4. Procedure of analysis

Quality control (cont.):

• qualified companies (technical intervention by experienced technicians and guaranteed the use of proper equipment for the protection and execution of the work);

• control of the application procedures (inspection of local conditions, of the surface / element to repair, inspection during the execution of each phase of the work);

• in-service inspection and maintenance (log sheet of rehabilitation / strengthening processes, monitoring, testing of initial load, periodic observations of the work).
INTervention Methodology

4. Procedure of analysis

o) Post-execution testing:

The intervention methodology must be integrated and developed since the beginning of the problem treatment until the delivery of the repaired or strengthened work. Therefore and in cases where justified, should extend the intervention to instrumentation and observing the behavior of the building over time.

p) Monitoring the future behaviour of the work:

- subsequent inspection;
- periodic maintenance actions.

Sound test to verify the state of the masonry after consolidation.
What is the procedure from inspection until resolution of such anomaly?
4. Procedure of analysis

Recommendations:

1. Characterization of cracking:
   - orientation (vertical, horizontal, diagonal or without orientation);
   - dimension, in mm, of the opening of the cracks;
   - incidence (low, medium or high);
   - location (identification of the construction element);
   - depth, in mm;
   - activity (active or null);
   - filling material (existing or not) and their characteristics;
   - evaluation of the moisture content.

2. Assessment of the most probable(s) cause(s);

3. Analysis of possible intervention technique(s);

4. Choice of materials / repair techniques;

5. Performing the intervention, including preparatory work and quality and safety controls;

6. Confirmation testing: subsequent inspection;

7. Performing periodic maintenance actions.
5. Chapter conclusions
5. Chapter conclusions

. The buildings begin to deteriorate from the moment they are built, in a normal and not revealing process of any design and execution flaws.

. The intervention methodology should evaluate the existent building and the possibility of eliminating the causes associated with the anomalies observed.

. There are several intervention forms that depend on several criteria: demolition / immediate replacement, wait and see, let it be, repairs (structural or non-structural), reinforcement, consolidation and protection.

. The procedure to follow should support the choice of the technical of intervention, ensuring the proper execution of the work and control the performance of the intervened element during its service lifetime.
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