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TREATMENTS FOR PATHOLOGIES OF BUILDING IN MOROCCO

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Abstract

The present paper focuses on the different pathologies that can affect both traditional and concrete buildings in Morocco, which can have adverse consequences on people's health and safety. These pathologies generate significant damages such as cracks waterproofing problems or structural deformations, even respiratory problems, and allergies for the occupants many solutions are proposed for the treatment of building pathologies in Morocco based on the data available in various scientific sources.

Keywords: Pathology, Treatment, Repair, Reinforcement, Lining, FRP Composite Material.

1. INTRODUCTION

The pathology and treatment terms are used in medicine to mean respectively disease a medicament, but in civil engineering, the pathology term means failure, disorder, damage or anomaly and the treatment term means repair or reinforcement. To address the topic of this paper, in this case, the treatment of building pathologies in Morocco (1), and considering the typology of buildings in Morocco, we selected the following research areas:

- Treatments of traditional buildings pathologies.
- Treatments of reinforced concrete buildings pathologies.

2. METHODOLOGY

Our methodology to study the treatment of building pathologies in Morocco is based on the data available in various scientific sources such as scientific papers, theses, unified technical documents, technical guides, the reinforced concrete regulations at limit states, reinforced concrete works, material resistance works, expert reports and laboratory tests. Our methodology for each line of research consists of two steps:

Step 1: Identification, analysis and diagnosis of damages.

Step 2: Appropriate treatments for the encountered pathologies.

3. RESULTS

The results of our research on the pathologies treatments in the traditional buildings and in the reinforced concrete buildings in Morocco are presented as exposed below in 3.1and3.2.

3.1 Treatments of Traditional Buildings Pathologies

The choice of the appropriate treatment to be carried out is deduced from the identification of the damage and the analysis of the causes of this damage. Proper shoring in the working areas to relieve the diseased parts of the existing structure is then required first before any repair or reinforcement action (2)

3.1.1 Treatments of Foundations

The causes of the pathologies of the traditional buildings foundations which are superficial and whose normal depth of the excavations varies between 0.80 m and 1.50 m, are multiple (3):

- Hydro geological nature of the foundation soil (presence of groundwater, clay soil, poorly compacted old fill, very compressible soil, etc.);
- Loads and overloads transmitted to the foundation soil, not compatible with the dimensions of the footings or with the bearing capacity of the foundation soil;
- Movement of the foundation soil (differential settlement, differential swelling, sliding);
- Earthquake (4)

All these causes lead to excessive deformations at the level of the soil-substrate interface of the load-bearing walls and pillars, these deformations are explained by the loss of foundation (5). The static balance of the building-ground is altered. It is then necessary to intervene their deformations. The adequate treatment to this balance problem and which adapts well with the traditional Moroccan building is the technique of the resumptions in under works by increase of the surface

of support and which consists in replacing the ground under the existing foundations of the bearing walls and pillars by a more resistant and broader support in stone masonry or in traditional full bricks or in big concrete or in cyclopean concrete to increase the surface of contact of the foundations with the ground and to reduce the constraints of compression at the level of the ground of foundations (6). This technique of underpinning also makes it possible to fill the cavities that may exist in the foundation soil 16 (7).

The treatment of the damage in the foundations their severity, if it is a question of small cracks, the repair is carried out by cleaning them and filling them with a lime mortar or with a bastard mortar and if the disorders in the foundations are important like fractures, thick cracks or detachment of large pieces of masonry of foundations then we remove the sick part of the foundation and replaces it with a new one built in stone masonry or traditional solid bricks with lime or bastard mortar (8).

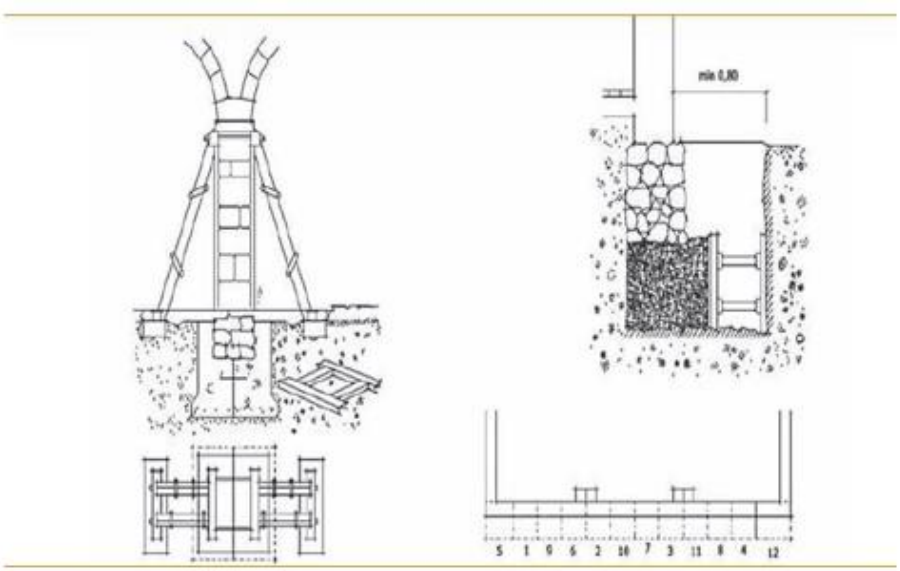

Figure 1: technique of underpinning under the footings.

3.1.2 Treatments of Load-Bearing Walls

The load-bearing walls of traditional buildings made of traditional stone masonry or traditional solid bricks are thick (thickness varies from 30 cm to 50 cm and even more in certain historical buildings). The causes of the disorders in the load-bearing walls are multiple.

- Deformations of the footings (excessive subsidence, excessive lifting, overturning, slipping).
- Excessive loads and surcharges transmitted to the loads and surcharges.
- Significant deformations in the floors.
- Earthquake.
- Adjoining excavations.
- Erosion in the external load-bearing walls due to climatic factors...

The techniques for repairing damage and disorders in load-bearing walls are multiple:

1. For the deterioration and detachment of the internal and external coatings of load-bearing walls, the damaged area is cleaned by removing the old coating and cleaning the masonry joints, then the cracked joints are filled with a new mortar and a new coat of lime-based coating is applied to the repaired areas.
2. The repointing: this technique consists in repairing the cracked masonry joints by cleaning them to a certain depth and then filling them with a new lime mortar or bastard.
3. The healing: it consists in disassembling the masonry on both sides of the crack by reassembling it and closing the opening created by using the same building materials of the repaired wall (stone or traditional solid bricks and mortar).

4. The use of staples: this technique consists in inserting between the lips of the crack or the cracking metal staples in U shape playing the role of sewing reinforcements, these staples are anchored perpendicularly to the crack and spaced from 50 cm to 80 cm in intact areas of the bearing wall.
5. Reinforcing the mechanical resistance of the load-bearing wall and its solidity in certain diseased areas, by inserting steel reinforcements inside the wall, using an epoxy-based adhesive product that ensures permanent contact between the reinforcements and the wall materials.
6. Replacing the diseased part of the load-bearing wall by demolishing it and rebuilding it with the same original materials (traditional solid bricks or stone and mortar).
7. When the balance of the load-bearing wall is in question, buttresses are used, which are inclined props made of stone masonry or solid bricks, placed to stop the tilting or tilting movement and therefore avoid its collapse.
8. Use of tie rods made of steel cables or bars fixed on two opposite walls to stop their tilting or spreading.
9. Installation of metallic chainings on the external perimeter of the building to fight against the tilting of the bearing walls of facades towards the outside and to reinforce their mechanical resistance. The chainings also allow keeping the shape o the building (9).
10. Excessive deformations of wooden door or window lintels cause arc-shaped cracks in the load-bearing wall as a result of the decompression of the part of the wall above the lintel. To remedy this, the work area is properly shored up and the existing deformed lintel is replaced with a new one of suitable dimensions and the cracks are repaired.

Figure 2: healing technique in load-bearing walls

3.1.3 Pillar Treatments

The interventions to treat damage to the pillars of traditional buildings are multiple:

1. When the masonry pillar has superficial or shallow cracks; the repointing technique is used to repair it.
2. To reinforce the solidity 98and mechanical resistance of a pillar in stone masonry or traditional solid bricks or marble or wood degraded, we use the strapping composed of wooden boards or planks and metal rings or steel cables tightened by bolts and nuts.
3. Substitution of the diseased parts of a traditional masonry pillar with others built with the same original materials (solid earth bricks or stone or marble) after proper shoring of the work area and dismantling of the degraded ar of the pillar.
4. If the masonry pillar is much degraded and presents a danger to the occupants, then it is removed after proper shoring of the work area and another pillar is rebuilt with the same original materials (traditional solid bricks or stone or marble).
5. If the wooden pillar is cracked, metal rings are used to contain it, but if the wooden pillar is much degraded, it is replaced with another wooden pillar at least similar, after suitable shoring of the work area.
6. To relieve a pillar and remedy the problem of excessive loads and overloads, one or two pillars are inserted in the immediate vicinity of the pillar to be reinforced, ensuring good ground support for the inserted pillars and respecting the descent of the loads (10).

Figure 3: rebuild of a traditional masonry pillar

3.1.4 Treatment of Arched Elements

For arches, vaults and domes of traditional buildings, the choice of the appropriate treatment depends on the health of the arched element. The following points should be noted:

1. To repair the areas of the arched elements were the renderings are cracked or detached, the old rendering is removed, these areas are well cleaned and the cracked masonry joints are repaired if necessary, and then a new rendering inlime mortar is applied.
2. When the existing structure of the traditional building isno longer able to absorb the tensions generate of the thrust the arched elements (arches, vaults, domes) on the supports (bearing walls, pillars) then the arched elements undergo excessive deformations and deviate from their initial position causing tilts of their supports. These excessive deformations of the arched elements are accompanied by cracks in the intrados. To stabilize and stop the deformations of the arched elements (arch, vault, dome), we use metallic tie rods made of steel cable or steel bars fixed appropriately in the traction zones to oppose the thrust forces generated by these arched elements and to stop the spread of the supports. Masonry buttresses are also used to absorb the thrusts due to the arches or vaults and to stop the spreading of the supports (bearing walls, pillars) of these arched elements. The cracks that appear in the intrados are then repaired using the same methods as for cracks in the walls.
3. If the arched element is much degraded and presents a danger for the occupants; it is demolished and replaced by a new similar element using the same original materials (stone or traditional solid bricks) to preserve the authenticity of the building.

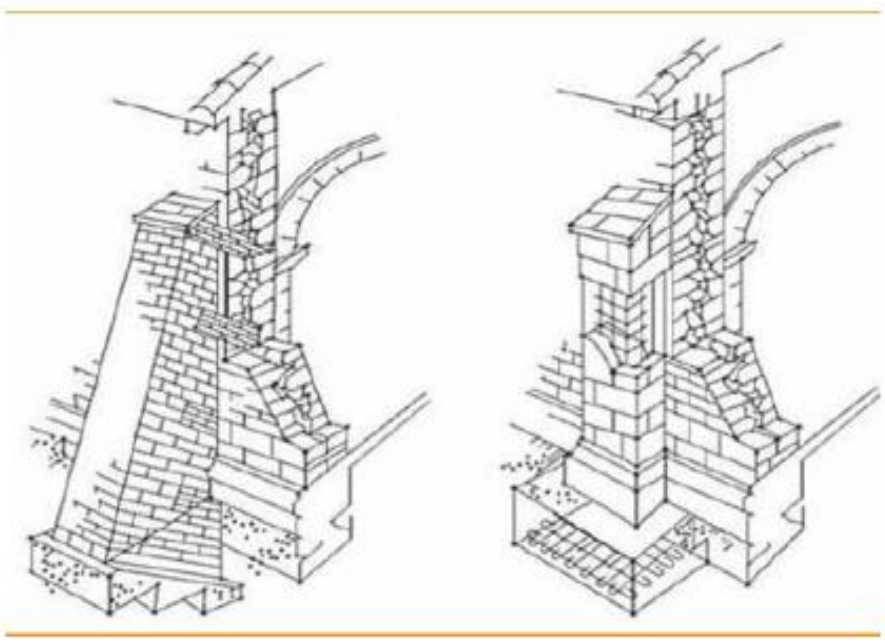

Figure 4: Use of buttresses to stabilize load-bearing walls and absorb the thrusts of arched elements

3.1.5 Treatments of Woodenfloors

The main causes and origins of deterioration in wooden floors and roofs of traditional buildings are:

- Excessive loads and overloads carried by the floor.
- Creep of the wood.
- The effects of thermal and moisture variations in the floor.
- Biotic attacks.
- Settling of load-bearing walls and/or pillars supporting the floor.
- Tilting of load-bearing walls.
- Bulging or crushing of load-bearing walls.

For interventions in wooden floors of traditional buildings, it is necessary to specify the following points:

1. Disorders in wooden floors are generally translated by cracks, excessive deflections, warping of wood, breakage and rotting of the wood of the structural elements (master beams, joists, decking, wooden frames). If the wooden floor has beams or joists that are too deformed or cracked and present a danger to the occupants. Due to loads and overloads on the floor, beams or girders are reinforced with wooden or metallic elements. These reinforcement elements are fixed, depending on the case, laterally or in the upper or lower part of the element to be reinforced by a suitable fixing system such as metal studs or similar (11).
2. In some cases, to remedy the problem of excessive deflections and creep deformations at the floor level, the spans are reduced by placing, in the middle, transversal beams made of wood or metal on the lower parts of the floor, ensuring supports for these transversal beams such as wooden or masonry or metal pillars and good footings.
3. The rotting of the wood floor is caused by a high moisture content in the wood and this favors the development of fungi and biotic attacks.

The biotic attacks are often observed at the level of the supports of the beams and joists which rest on bearing walls and pillars presenting a significant moisture rate. The disorders are translated by rotten supports. Water infiltration in the wooden floor due to defective waterproofing of terraces or roofs also leads to this problem of rotting of the floor wood. To remedy this pathology of rotting of the beam supports, we have two solutions:

a. Cut the diseased supports and replace them with new ones and use a curative treatment of the floor wood with a xylophone solution or paint or varnish. The connections of the new supports with the beams or joists must be done carefully.
b. Reinforce the diseased supports after their cleaning and treatment with a xylophene solution or paint or varnish, with metal shoes that will cover the diseased supports (12).

Figure 5: Reinforcement of the wooden floor by reducing its span

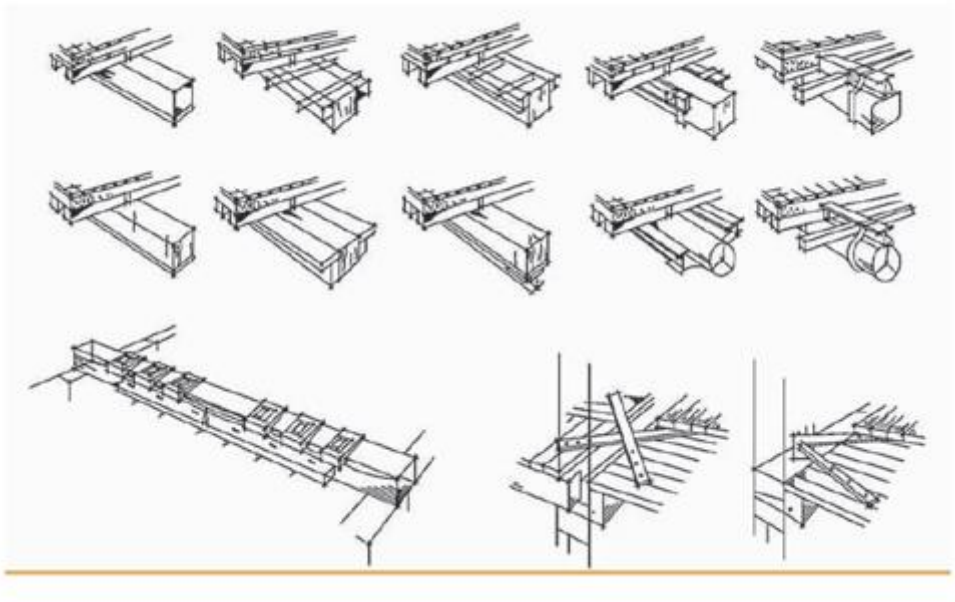

Figure 6: Reinforcement of wooden floor beams and girders withmetal or wooden parts (13)

3.1.6 Foundation Treatments

Cracks in reinforced concrete foundations at the level of footings, stringers, chaining, foundation walls or rafters are filled with an epoxy binder injected under pressure or with a hydraulic binder such as cement mixed with a resin after widening and cleaning the cracks. When the surface of the concrete of a foundation element is degraded and too cracked or there are detachments of concrete, then it is repaired by applying a generalized protection by a coating which closes the cracks, restores the shape of the repaired element and ensures a sealing to water and other aggressive agents. For the treatment of foundation pathologies (14), the following points are important: When the damage in the reinforced concrete building is caused by a loss of mechanical resistance of the foundation soil, it is necessary to intervene on the foundation soil to consolidate it and improve its mechanical resistance and on the foundations to adapt them to the loads and solicitations supported (15).

The most widespread and tested techniques for improving the soil and reinforcing the foundations of reinforced concrete buildings are as follows:

a. Rehabilitation by increasing the support surface: this technique consists of replacing the soil under the threaded or insulated footings by a larger and more resistant mass of concrete or stone masonry. The aim is to increase the contact surface of the foundations with the ground to reduce the compressive stresses transmitted to the ground (16).

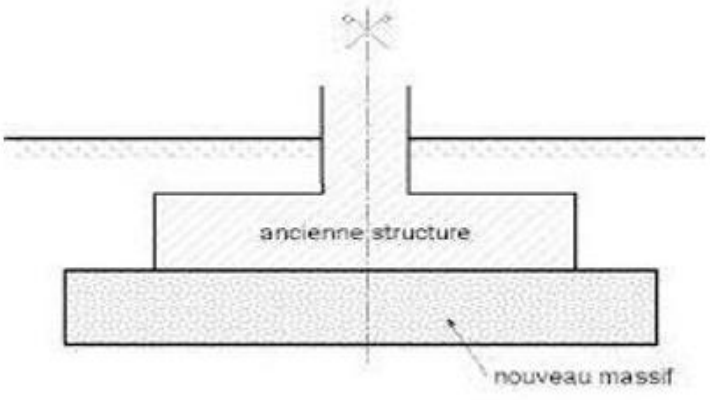

Figure 7: Underpinning by İncreasing the Bearing Surface (16).

b. Width reinforcement: this technique consists in increasing the dimensions of the footing by adding new reinforced concrete foundations poured on both sides of the existing footing at the same depth. The purpose of this technique is to reduce the compressive stresses at the soil- footing interface (17). The new parts must adhere to the existing footing to ensure the monolithic nature of the footing (18).

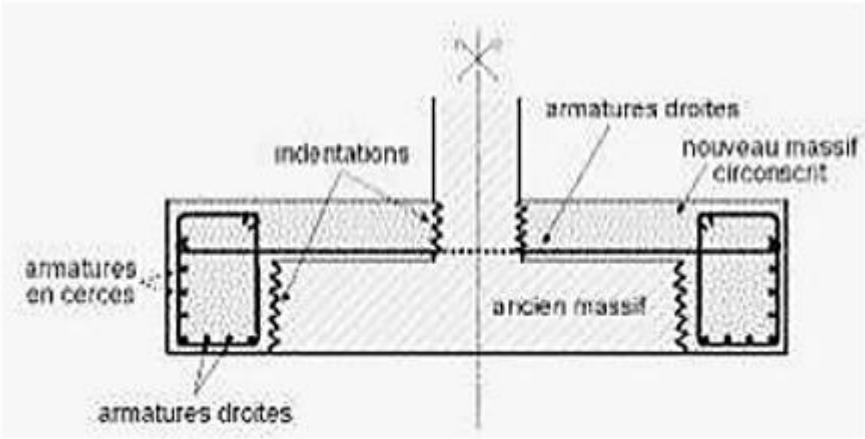

Figure 8: width reinforcement of a footing (19).

c. The resumptions in height which consist in increasing the height of the existing footing and the section of the corresponding column.

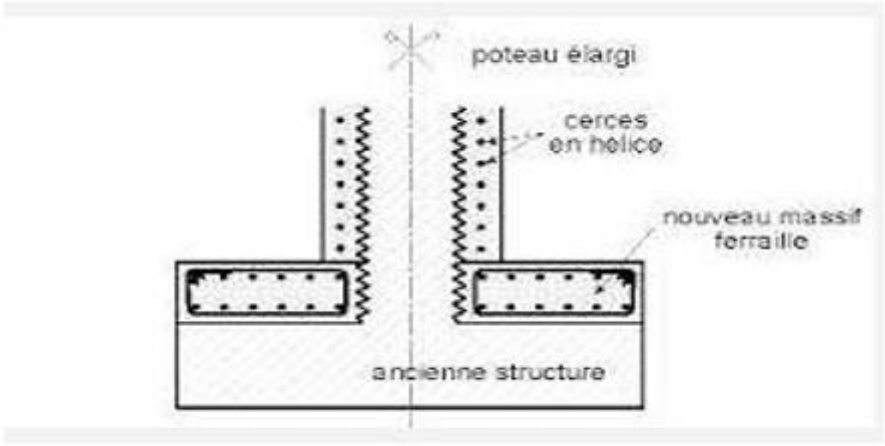

Figure 9: Height recovery of a reinforced concrete footing (20).

d. The use of micro-piles or concrete shafts: it is a technique which consists in transferring the loads in depth and the level of the foundations to a lower level where the ground is of better mechanical resistance by anchoring micro-piles in reinforced concrete or metal (21).

Figure 10: micro piles reinforcement of foundations.

Figure 10: Expanding resin injection technique in the foundation soil.

1. When the foundations of the building are stable on good soil and we want to reinforce the load transmission capacity of the existing columns because we want to raise it by one or two levels or change its use (increase of the operating loads) and the existing reinforced concrete structure does not allow it, or the damage is caused by a defect in the design of the foundations, or deteriorated foundation elements, the technique of lining the footings, stringers and chains is used by increasing their dimensions (length, width, height) and their reinforcement and consequently their bearing capacity and mechanical resistance (22).

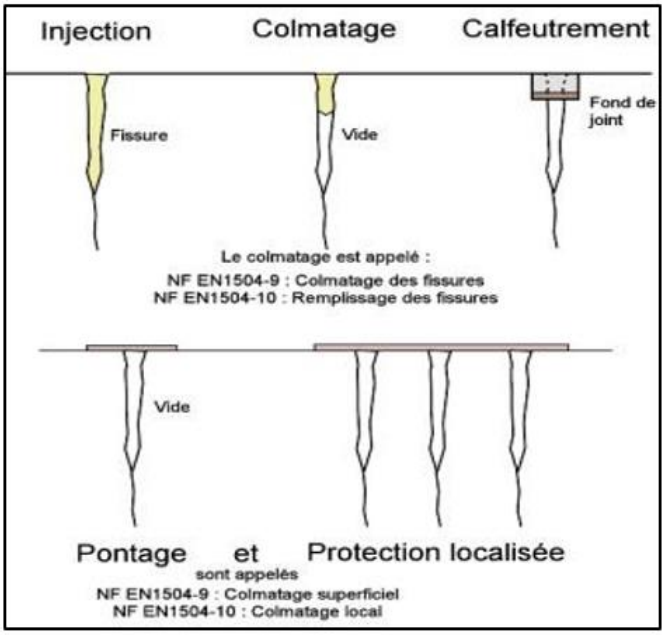

Figure 11: lining of an insulated reinforced concrete footing

2. When in a building cellar, a reinforced concrete wall has a tendency to tilt inwards, reinforced concrete buttresses are installed inside it or it is reinforced by lining to increase its thickness. The purpose of these two solutions is to stop the tilting, to reinforce the mechanical resistance of the underground wall and to properly absorb the thrusts exerted on this wall (23).

When the reinforced concrete slab of the building platform sags or lifts, cracks appear in the ground covering, this disorder is often the consequence of a bad compaction of thebad backfill made of clay or earth that can collapse in the cracks, one must apply a generalized protection by a waterproof presence of water. To remedy this problem, it is necessary resinous coating on all the cracked surface to close all the cracks.

to remove the existing paving and possibly eliminate the d-The chemical products used to treat the cracks of the source of water circulation and provide a new backfill of reinforced concrete are numerous: epoxy resins, silicon resins, good quality, which must be well compacted and then urethane resins, resinous cement grout. These products have the create a dry-stone blocking topped with a synthetic vapour property of non-shrinkage.

3.2. Treatment of reinforced concrete structural elements of the structure

The treatment of a reinforced concrete structural element varies according to the nature of the defects or damage observed on this element.

3.2.1 Treatment of cracks in structural elements

Cracks in reinforced concrete structural members such as columns, walls, beams, girders or solid slabs must be observed for at least 30 days to see if they are dead or active, using plaster gauges or similar. The causes of the cracks must be determined and treated appropriately. For the treatment of cracks in concrete, the following points should be specified:

a. The repair of cracks in reinforced concrete elements ensures, on the one hand, the monolith of the repaired element so that it can continue to perform its function in the structure of the building and on the other hand ensure the impermeability to air and water to protect the reinforcement in the cracked areas (24).

b. When a structural element has dead cracks that are not considered dangerous, these localized cracks are repaired by cleaning them of dust and saturating them with water and allowing them to dry, then injecting them with a specific resinous material (epoxy) applied by spray gun or with a cement grout mixed with resin, after checking that the reinforcements are in good condition. In the case of active cracks, it is necessary first to determine the causes of the cracks and to remedy these causes, then to repair these cracks by cleaning and injecting them with a resinous material associated with a synthetic or fiberglass anti- cracking fabric (25).

Figure 13: cracks protections

Concrete walls-slab-beam) cracks or detaches because of loads and overloads or chemical attacks or design defects or other causes, it is necessary to repair this element or to reinforce it, the techniques are multiple according to the observed case:

a. Technique of cleaning the corroded reinforcements.
b. Technique of replacing the corroded reinforcements.
c. Technique of lining by welded angles and flat iron.
d. Technique of reinforced concrete lining:

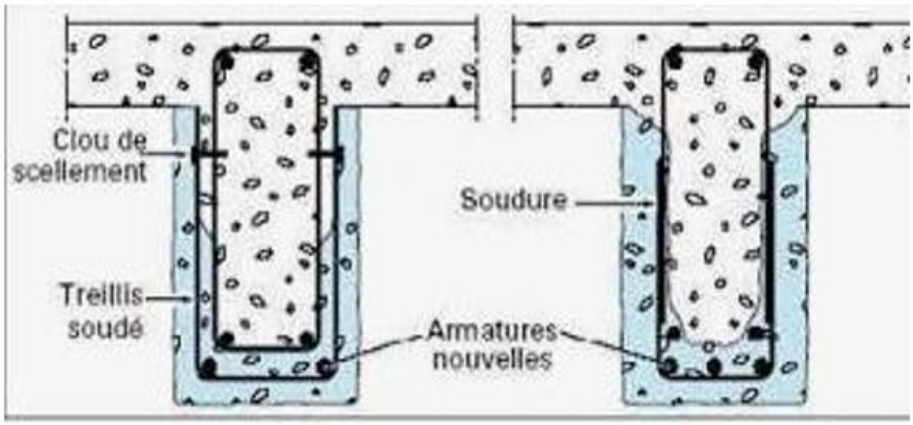

Figure 14 and 15: reinforcement of beams and columns with angle iron jackets and flat iron.

Figure 16: Lining of reinforced concrete columns

Figure 17: lining of reinforced concrete walls.

e. Treatment of the columns by reinforced concrete collars.
f. Technique of reinforcement of the structure by metallic profiles:

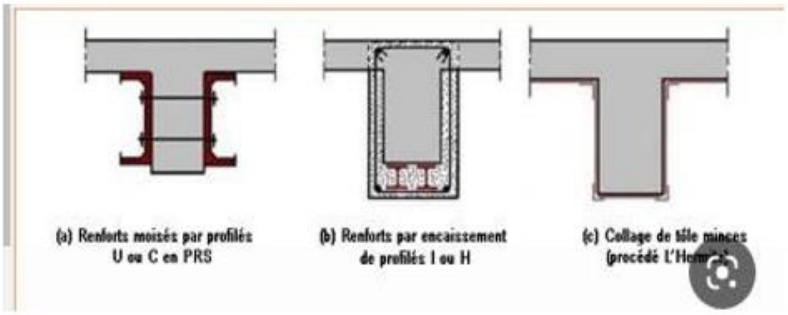

Figure 18: Reinforcement technique for beams with metallic elements

Figure 19: Reinforcement of a reinforced concrete structure with metallic elements

g. Technique of implantation of structural elements in reinforced concrete.

h. Technique of bonding to the surface of thin metal plates. i-Technique of bonding to the surface of composite material parts made of carbon fiber reinforced polymer CFRor glass fiber GFRP (26):

Figure 21: Floor reinforcement with CFRP composite material

3.4 Treatment of Masonry

In the reinforced concrete buildings in Morocco, the masonry consists of non-load-bearing partition walls in red clay hollow bricks or in concrete agglomerates. The main facades are constituted by double partitions to ensure a thermal insulation of the building. The renderings of the walls are in cement mortar or plaster.

3.4.1 Treatment of Fissures in the Walls

Cracks in masonry are superficial if they only affect the rendering; these cracks in the rendering (micro-cracks, crazing, cracks) are caused by poor workmanship or by the phenomenon of shrinkage (rendering that is too fluid and dries too quickly).

These cracks in the rendering that do not evolve do not present any danger to the building and are easily repaired with a filler. If the rendering is degraded or there is detachment of the rendering, it is stripped and replaced by a new rendering.

Cracks in bricks or agglomerates are active if they widen and deepen with time and inactive or dead if they do not. The cracks encountered in the masonry of the building are multiple. Before repairing masonry cracks, it is necessary to observe the evolution of these cracks for at least 30 days to know the degree of importance of these cracks with regard to the safety and stability of the building; plaster or glass witnesses or gauges (crack-meters) are used on the edges of the cracks. The causes of the cracks in the masonry must be eliminated first and the cracks repaired second. The materials used in the treatment of cracks in walls are:

- Epoxy based on filler (25).
- Cement mortar with non-shrinkage properties.
- Silicone paste.

Figure 22: Anti-Cracking Strip

Figure 23: Repair of Cracks in Wall with Epoxy-Based Coating.

3.5 Treatment of Deformations in the Walls

If a wall has excessive slope or transverse deformation or the bricks are disassembled and the masonry joints are badly damaged over a large area, the diseased part must be dismantled and rebuilt (26).

3.5.1 Treatment of Humidity in the Walls

Before treating walls for dampness, it is necessary to determine the causes of the dampness and then take the necessary actions to stop the excessive dampness. To treat the walls affected by moisture, remove the rendering in the areas affected by moisture to clean them of mold and possible saltpeter and make them dry, apply a new waterproof rendering and then add a protection on the rendering, using an anti-moisture paint or a wall covering in ceramic tiles or marble. Sunlight and ventilation of the building are mandatory to avoid the harmful effects of humidity on the health of the occupants (27).

Figure 24: Mold or black spots in wall to be cleaned with bleach

4. DISCUSSION

The treatment of pathologies encountered in the structures of traditional buildings or reinforced concrete buildings in Morocco varies according to the location of the damage and their causes. This treatment can be easy to carry out and less expensive

or complicated and more expensive as in the case of repairs and reinforcements of the foundations of the building because the access to the foundations is often difficult, indeed, it requires excavations in the perimeter or inside the building which is often not isolated from the other constructions and consequently additional works are to be envisaged like the repair of the pavements and the ground coverings and possibly of the underground pipelines.

The cost of the treatment of the pathologies of building is variable according to the nature of the works of repair or reinforcement to be realized. It also depends on the materials and products to be used and on the manpower which must be specialized in the maintenance works. Concrete building preventive measures during theconstruction work must be respected to reduce the appearance of cracks and excessive deformations and to fight against humidity. Compliance with the regulations and standards in force in the field of building construction is the only way to achieve this.

5. CONCLUSION

The treatment of the pathologies of traditional buildings which represent a cultural heritage of Morocco or of reinforced concrete buildings, makes it possible to preserve them in good state thus to prolong their lifespan and to exploit them in conditions of safety and comfort. A good knowledge of the ground of foundations and a good conception and study of the building combined with a good realization of the works and a good quality of the building materials, allows avoiding the appearance ofdangerous pathologies whose treatment is expensive. The periodic maintenance of buildings is a necessity that must be considered by the owners to ensure their durability.

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