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EXTENDED ABSTRACT

TECHNOLOGY AND REHABILITATION OF INNER GYPSUM PLASTERS

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EXTENDED ABSTRACT

1. INTRODUCTION

The main subject of this dissertation is inner gypsum plaster (IGP), although some analogies have been established with pre-dosed synthetic plaster, emphasizing its similarities and its differences. Traditional plaster has also been referred, pointing out the remarkable evolution. The updated plaster technology is presented and several repair techniques have been suggested and classified, which are connected quantitatively with the defects of this gypsum plaster, through the **correlation matrix defect - repair techniques**. The theorical model created was validated through the inspection of 87 rooms and all the data collected in this phase was statistically treated.

2. TECHNOLOGY

In Portugal, plaster has been used since the XVI century, however, it only was publically known in 1764, when the marquis of Tomar created the Plaster and Drawing Class. Generally, its artistic and historical value was associated to the final touch of gypsum plaster, according to the architectonical styles used. Therefore, the traditional plaster could receive several types of finishing, like surface polishing, several types of painting, colored final touches in the gypsum plasters and decorations, according to the beauty standards of each age. This final gypsum plaster, known today as old or traditional plaster, was exquisitely set by hand and the walls had the following coats, which strength decreases through the support: scratch coat and undercoat, which can be executed by one or two coats; first and second undercoat as well as the finishing coat, composed by the preparation coat and the gypsum finishing coat. It was common to use several coats due to the poor conditions of flatness and un-warping of the old buildings´ supports which interiors were normally made of plaster. In what regards the walls, continuous supports (like concrete, brick masonry as well as clay and concrete blocks), slab or panel supports (from which gypsum plate reinforced with linen and cork or glass wool stand out) and crated supports stood out. The ceilings´ supporting structure was placed under the floors framework or it was made as an independent framework.

However, the work´s profits demanded today became incompatible with the design and application methods of the traditional plaster. This fact, associated to the good flatness and un-warping conditions of ordinary supports, like expanded clay concrete, autoclavated aerated concrete and framed concrete of ordinary joints, made possible the regularization and the finishing of the surface with minor density gypsum plaster - from 1 to 3 mm in synthetic pre-dosed plaster and from 10 to 20 mm in pre-dosed gypsum plasters. Therefore, in spite of the fact that the traditional plaster had lost its artistic value in contemporary buildings, the good relation between costs and quality, as well as the easiness and quickness of performance associated to ordinary gypsum plaster, conferred it 75% of inner gypsum plaster in Portugal.

In theorical means, the quality of IGP is guaranteed through the fulfillment of the six essential demands of the 89/106/CE law, regarding the construction products (EE1 - stability, EE2 - security against fire risks, EE3 - hygiene, health and environment, EE4 - use security, EE5 - protection against noise and EE6 - energy saving), as well as the specific demands that depend on the type of cladding. Therefore, in what regards gypsum plasters, the density conditions, flatness, plumbness, superficial steadiness, support´s stickiness, resistance to flexion and compression, fixing resistance and the development of mould, fixing time and durability, should be verified according to EN 13279: 2005, in D.T.U. (*Document Technique Unifié*) n.º 25.1 and in experiment charts of the LNEC (National Civil Engineering Laboratory). In what regards synthetic

gypsum plasters, the quality rules are the saponification resistance, flatness, plumbness, superficial steadiness, support´s adherence, impacts´ resistance, friction, water and dirt, resistance to setting and the development of mould and durability.

Ordinary plasters have the double function of regulating and finishing, which correspond to the regulating and finishing coat. However, the gypsum plasters differ in the way they are commercially presented. Plasters based on gypsum are composed by pre-dosed mixtures that are done at the factory, to which water is added only to make the pulp. Synthetic plasters are sold already prepared, but eventually there's the need of adding a small amount of water by the time of its setting.

Plasters are composed by one or more binders (hemi-hydrated calcium sulphate, anhydrite and burned lime), loads (expanded silicate, siliceous sand and calcium carbonates) and adjuvants (stickiness delayer, plasticizers, water retainers and thickeners). The difference between the products that are used in regularization and the ones used in finishing are mainly in what regards the measurement of the loads´ grains, which is minor in the finishing and these are sold in kraft paper bags. Plaster is called light, if low density loads are used (inferior to 800 kg/m^3), which are only recommended for mechanical usage. After setting the plaster coats, it is always advised to do a final coloring touch, appropriate to the type of space in which it is set, in what regards the decorative functions as well as the degradation inherent to its usage, in spite of the fact that efficient ventilation is always the best solution to prevent defects. In these conditions, gypsum plasters can be set in any kind of inner surfaces.

Pre-dosed plasters based on gypsum can be set in almost every common supports, as long as they have compatible measures with its gypsum plasters, in spite of the fact that sometimes it is necessary to submit it to a mechanical treatment or stuffing. Still, the use of this kind of cladding is not advised over building cement, due to the formation of expanded salts, when there is humidity, causing as a result the loss of adherence.

In an early stage of the work´s project and planning, there should be minimal conditions to protect the surfaces from the rain´s trespassing. The plaster´s setting and its drying should be coordinated with all the other work activities, in order to prevent the production of substances or actions that will prematurely contaminate or damage the inner gypsum plaster (IGP). Besides, the gypsum plaster´s setting should only take place between 4 to 6 weeks after the surfaces are completed, which can differ according to the type of material that it is used and the climate conditions.

By the time of its setting, the supports should be stable, united and free of any kind of product that can prejudice the gypsum plaster´s adherence. On many straight supports, the setting of the plaster should be preceded by a first coat with the function of adherence or surface puncturing. On very absorbent supports, there should also be applied a first coat in order to regulate the water's absorption. The support´s prominences which size overcomes one third of the gypsum plaster's average thickness should be polished and the recesses with more than 10 mm should be fulfilled. The gypsum plasters´ setting should only take place when the environmental temperatures are between 5 to 40º C and when air humidity is not extremely low.

The preparation of the regulating and finishing products is made mechanically. In the first case, it is made in projection machines, in which it is introduced a pre-dosed powder and the water´s entrance is controlled, whereas in finishing coat products, the pulp is obtained through the addiction of water into the powder that

has been previously placed in a specific recipient and has also been homogenized with the assistance of a mechanical mixer.
The setting of the regulating coat is done directly on the support, on continuous horizontal stripes (**Figure 1**), creating a unique coat which is stretched and straightened with a metallic ruler while the pulp is still fresh (**Figure 2**) and, after hardened, it is straightened or polished with a spatula (**Figure 3**) and it is scratched with a metallic trowel. The finishing coat is executed between 4 to 24 hours after the conclusion of the underlying layer. This is done with the aid of a metallic trowel and spatula, in order to obtain a straight and un-warped surface as much as possible (**Figure 4**). In the setting process, it is important to stand out the reinforcement made with net or plastic side-faces, which should be done in specific points, such as span tops, areas of the support that are continuously coated or superficially cracked, existent joints on the support and prominent arris. In the intersection of the wall and the ceiling, border areas are frequently done with an ogee or a cove.

Figure 1: Regulating coat projection

Figure 2: Straightening with a ruler

Figure 3: Straightening with a spatula

Figure 4: Application of a finishing coat with trowel

After setting the inner gypsum plaster (IGP), the area where the work is being done should remain open and with moderate ventilation, in order to permit the correct drying of gypsum plaster, which can only receive its definite finishing after a break of 30 to 45 days, according to the climate conditions and sun exposure.

The suitable maintenance of IGP implies a pro-active predictive maintenance strategy. This means that in an early stage of the project, one should do a maintenance plan, in which all the inspections that the building will have to face should be predicted and, according to the reports that will be made, decide the actions that should be taken. All the inspections should have its own method, be based on appropriate diagnosis techniques and also have as its main purpose not only gypsum plaster, but also its surroundings. In what regards all the actions that have to be taken, regular cleaning and located repairs are normally the more frequent options. Regular cleaning has the aim of preventing defects, as well as guaranteeing the maintenance of gypsum plasters in what regards its esthetics. The located repairs eliminate a certain defect, avoiding it from spreading, and it can improve the initial level of quality of gypsum plaster.

In what regards the probable characteristics of its development, pre-dosed plasters based on gypsum should not present permanent degradation, while in contact with humid alkaline supports, as long as it is only temporary. It should also reveal good resistance to impacts, good adherence to the support and moderate elasticity module. On the other hand, they show little resistance to the actions of water friction and to the rising of stains, when compared to traditional plasters set over plastered masonry. This problem can be partially solved if a suitable final gypsum plaster is set by coloring.

Synthetic pre-dosed plasters are composed by binders based on synthetic resin of watery diffusions, loads (normally calcite or quartz), several adjuvants, pigments and water. Just like the pre-dosed gypsum plaster, the main difference between the synthetic products used on the regulating and the finishing products is the

measurement of the loads´ grains. These components are mixed at the factory; therefore, they are presented in a pulp form, are packed in polyethylene bags and are ready to be used.

Synthetic pre-dosed plasters can be set directly on supports which global and local flatness is compatible with the density in which they are applied, which makes its field of setting more reduced than the ones based on gypsum. Therefore, in both claddings, the conditions required at the moment of setting are similar in these two plasters, excepting in the case of the synthetics, because recesses should not exceed 5 to 8 mm and prominences can´t have more than 2mm. Besides, the setting of inner gypsum plaster should only take place when environmental temperatures are between 5 to 30ºC and humidity should not exceed 90%.

The setting places and the measures to be taken during the project phase are similar to all that has been said about the pre-dosed plaster based on gypsum.

The regulation of the surface is normally done by mechanical projection, which can only be executed through the use of projection equipment required to the setting of textured ink. This coat is set with two or three first coats, with a break of at least 12 hours between the settings of each coat. After setting each coat, the surface should be straightened with a metallic spatula. The finishing coat should only be set after a break of at least 48 hours. The number of first coats and the used method depends on the type of finishing required, which can be straight, rolled up or thrown. If one wants it straight or rolled up, it is required only one first coat of the product, which can be applied by hand or mechanically. If one wants it thrown, it will be necessary to apply a second hand coat which will be set with a projection gun. The straight finishing is obtained through the abrasion of the finishing coat, which can only be done 48 hours after its setting. To obtain the rolled up finishing, one should apply an appropriate roller over the surface while the product is still fresh.

The treatment of specific points, as well as the maintenance of the gypsum plaster and its drying conditions, is similar to what is done in the pre-dosed inner gypsum plasters, with the exception that the synthetic plasters can receive a final finishing 48 hours after its setting.

3. PATHOLOGY

The most common plaster based on gypsum defects occur as a result of natural, chemical and mechanical phenomena, which are explained on **Chart 1**. However, the most appropriate repair solution depends on, not only of the type of defect, but also the combination of other defects and its causes, which can determine the steadiness or development of these abnormal phenomena.

The causes of these defects can be direct or indirect. The first situation happens when the phenomenon causes almost immediately a certain defect, whereas an indirect cause requires the combination with a direct cause, in order to promote the decay process.

Humidity (**A-F1**) and dirt (**A-F2**) stand out from the defects of physical origin. Beyond being a pathological phenomenon known as stains on the top of the surface, humidity is also the main direct cause of the defects that are detected upon plasters based on gypsum, especially chemical defects, when the cladding is exposed to humidity during a long period of time. Dirt (**A-F2**) is the concentration, permanent or temporary, of microscopic fragments upon a plastered surface, which macroscopically are colored stains that can change

according to the kind of fragment and its level of impregnation in gypsum plaster. These defects can be corrected simply by cleaning (**R-A1**) the affected surfaces.

Chart 1: Defects´ classification

A-F - PHYSICAL
A-F1 Humidity
A-F2 Dirt
A-Q - CHEMICAL
A-Q1 Bio-deterioration
A-Q2 Efflorescences and crypto-efflorescences
A-Q3 Loss of adherence
A-Q3.1 Unpasting
A-Q3.2 Arching
A-Q3.3 Detachment
A-M - MECHANICAL
A-M1 Cleaving
A-M1.1 Superficial cleaving in map form
A-M1.2 Deep or very deep linear cleaving
A-M1.3 Medium cleaving
A-M2 Dints and impacts
A-M3 Loss of cohesion / disaggregation

From the defects of chemical origin, one has to stand out the following: the bio-deterioration, the efflorescences and crypto-efflorescence and several levels of adherence´s loss - unpasting, arching and detachment. Bio-deterioration occurs because of the fixation and development of micro-organisms upon the gypsum plaster´s exterior and is normally connected to the long term presence of humidity in the surfaces or to inadequate ventilation. The efflorescences and crypto-efflorescence are soluble salt crystallization located upon the gypsum plaster´s surface (efflorescence) or in the interior of its pores (crypto-efflorescence). The first one presents superficial stains and the second one presents loss of adherence, caused by the volumetric expansion that comes with the salt formation. The loss of adherence can be explained by the existence of discontinuities between the inner gypsum plaster and the support in located places of the surface (unpasting), which can lead to the creation of convexities (arching), and as a result it causes the detachment from the wall (detachment). These defects may have several causes, for example it can be a consequence of the fact that the support is too straight and has pores, or probably there was too much water on the support while the plaster was being set, or it is the consequence of the crystallization of soluble salts or hygroscopes, it can also be the consequence of differential movements between the support and gypsum plaster or, at last, it can just be the consequence of the volumetric expansion associated to the oxidation of metallic elements.

The mechanical defects can be cleaving (**A-M1**), dints and impacts (**A-M2**) and the loss of cohesion/ disaggregation (**A-M3**). Cleaving is classified according to the extent and depth of the fissure, as well as by its appearance. Indeed, a less critical cleaving is only superficial, its regular extension is less than 0,2 mm and its depth is smaller than the finishing coat. This kind of cleaving has normally a mapped shape and generally its origin is the gypsum plaster, due to its retraction during the hardening process (**A-M1.1**). Medium cleaving (**A-M1.3**) has between 0,2 e 2 mm of amplitude and it doesn´t cross, in normal conditions, all the density of gypsum plaster. Its origin can either be in gypsum plaster, in the support or be the consequence of thermic and hygrometric changes, or casual impacts. Deep or very deep linear cleaving (**A-M1.2**) has normally its origin in gypsum plaster, due to supports´ movements caused by hydric, geological, dynamic reasons or others, which are all related to its constructive elements. Dints and impacts (**A-M2**) are permanent deformities in gypsum plasters, normally caused by accidental mechanic actions. The loss of

cohesion / disaggregation (**A-M3**) is the disconnection of gypsum plasters´ elements, which can easily disintegrate and, as a result, lead to fragmentation. This defect is associated to the crystallization of salts connected to the dissolving action of the water, which percolation inside gypsum plaster vanishes the binder (calcium sulphate), disconnecting all the components of the plaster, creating cavities inside the plaster that will promote salts´ crystallization.

Synthetic plaster has, in general means, the same defects that plaster based on gypsum has, in spite of the fact that the formation process is different, with the exception of the efflorescences and crypto-efflorescences, which do not occur in synthetic plaster. The loss of adherence is usually related to the binder´s saponification, due to the attack of the alkalis contained in the support´s material, when it is humid. In what regards gypsum plaster, this defect is caused by salt crystallization. Synthetic plasters are more exposed to cleaving, which occurs as a consequence of the support´s movements, due to its minor density, which becomes more critical, because its elasticity diminishes as time goes by, when it is exposed to UV radiation. Anyway, synthetic plaster doesn´t have to go through dissolution cycles - solution of soluble salts that are a part of its composition.

4. REPAIR

Similar to what happened to the evolution of the design and setting methods of the inner gypsum plaster, the repair techniques also changed, which transformed the traditional techniques such as consolidation, hardening and surface conservation as well as the re-integration of plaster ornaments into outdated techniques. These actions only made sense in old buildings, in order to preserve its artistic value.

The repair interventions can be classified as **corrective reparation techniques** (**rc**), **maintenance works** (**m**) and **preventive maintenance techniques** (**rp**). The first one will eliminate, repair and disguise or cover-up the defect, whereas the maintenance works will prevent or correct smooth or unsubstantial degradations of the building. The preventive maintenance techniques are interventions that are really necessary in order to eliminate its cause, although it will not repair directly the defect.

The repair techniques that were presented were divided into four groups, so that each one corresponds to the interventions related to each element of inner gypsum plaster (**R-A - Inner gypsum plaster surface** or **R-B - Finishing coat**), its total (**R-C - Inner gypsum plaster)** or its impact zone with its applied support (**R-D - Support contact)** (**Chart 2**). Each repair technique has its own correspondent repair chart, with detailed description of the process.

The **cleaning process of the IGP** (**R-A1**) changes according to the kind of finishing, the existence or inexistence of a final colored finishing and, in this case, the kind of ink used. Generally, the cleaning of colored finishings, as long as the used ink allows it, is made through a simple dry process of removing the dust, smooth brushing with water or with neutral liquid detergent and, in this case, it has to be washed with water. If gypsum plaster is not colored, its cleaning can´t be done with humid products; instead the stained area should be lightly polished. The cleaning method is efficient only in defects with a superficial development; however, it can be used associated to other techniques, such as **R-A2** (**fungicide application on IGP surface**) or **R-B2 (narrow coat application over the existent IGP**). **R-A1** technique may also include coloring or re-coloring of the surface, and, therefore, may resolve the loss of adherence just between gypsum plaster and its painting.

The aim of the **fungicide application on IGP surface** (**R-A2)** or the **fungicide incorporation in the IGP** (**R-C4**) is only to correct or prevent the occurrence of **A-Q1** defect (**bio-deterioration**). **R-A2** technique consists on a sterilizing wash, followed by a superficial application of the fungicide, which can be directly applied and, three days later, it can be removed simply by brushing it or incorporating it in the ink. This solution is suitable when the defect only shows superficial development and gypsum plaster hasn´t been irreversibly damaged and it is still stable. In all the other cases, the most suitable method is **R-C4**, which consists on the replacement of gypsum plaster in the affected areas, adding a fungicide agent in the finishing coat, which will give fungicide properties to the IGP. In this case, coloring the cladding is optional, in spite of being the most conservative option. Nevertheless, both techniques referred throughout this paragraph present one disadvantage: the fact that fungicides only have a temporary effect.

Chart 2: List of curative repair techniques (rc), preventive (rp) and maintenance works (m)

R-A INNER GYPSUM PLASTER
R-A1 IGP cleaning (rc /m)
R-A2 Fungicide application on IGP surface (rp)
R-B FINISHING COAT
R-B1 Fissures fulfillment (rc)
R-B2 Narrow coat application over the existent IGP (rc)
R-C INNER GYPSUM PLASTER
R-C1 Entire or partial replacement of the IGP (rc)
R-C2 Net incorporation in the regulating coat of the IGP (rc)
R-C3 Protection of the prominent arris (rp / rc)
R-C4 Fungicide incorporation in the IGP (rp / rc)
R-C5 Removal / replacement of metallic element damaged and plaster reparation (rp / rc)
R-C6 Localized reinforcement with staples of the IGP (rc)
R-D SUPPORT CONTACT
R-D1 Local detachment of gypsum plaster (rc)

Fissures fulfillment (**R-B1**) consists on opening the fissure in "V" or in rectangle, followed by the removal of the free material that is inside the created cavity and then it is fulfilled with the finishing material. This action can only be localized, and in this case it should be enriched with the surface coloring in at least one of the areas delimitated by the arris, or the fulfillment can be spread to a major area, delimitated by arris. These actions aim to obtain a homogeneous finishing. The **R-B1** technique can only be used in stabilized and superficial fissures which holes are superior to 0,2 mm.

The **application of a narrow coat over the existent IGP** (**R-B2**) is the scratching of the affected surface, followed by a toxic wash and the application of a new finishing coat, when gypsum plaster is already dry. Therefore, this method allows the gypsum plaster´s renewal and is always efficient in hiding defects, such as stains that can´t be removed with cleaning. This is the most suitable solution for defects that are stabilized and when its depth does not exceed the plaster´s finishing coat, which can be the case of **dirt** (**A-F2**), **bio-deterioration** (**A-Q1**) or superficial cleaving.

The **entire or partial replacement of the IGP** (**R-C1**) is the extraction of the affected areas from the gypsum plaster and its replacement with the same products. It is suitable for stabilized defects that include the regulating coat or defects that had irreversibly damaged the gypsum plaster in a major depth to the correspondent to the finishing coat.

The **incorporation of net in the regulating coat of the IGP** (**R-C2**) is similar to the previous technique, differing only in the fact that the extraction exceeds the affected areas in about 20 cm, if the defect occurs isolated, or in 10 cm, if the defect is generalized in the surface area. Besides, in the replacement of gypsum plaster, there should be added two first coats of the regulating coat, a net (glass fiber with anti-alkaline protection or metallic protection against corrosion) in gypsum plaster, in order to increase locally its resistances to traction. Indeed, this method is suitable to correct instable fissures caused by continuous gypsum plaster in the heterogeneous areas of the support, by the concentration of tensions, by superficial fissures that re-open (due to humidity changes that occur during the different seasons) and cleaving originated on the support (although this is not the most suitable technique for this effect). This measure is more efficient when it is set since the beginning and in the general area of the surface.

The **protection of the prominent arris** (**R-C3**) can be resumed to the effort of these zones through the incorporation of plastic side-faces between two first coats of regulating coat, which gives not only a more accurate finishing, but also a major resistance to impacts. Nets can be associated to the side-faces and its advantage is to provide an increase of resistance to the traction of the embraced area. Gypsum plaster´s removal must be done by exceeding the area that has to be reinforced in 5 e 10 cm, whether the side-face has to be set isolated or associated to a net. The incorporation of plastic side-faces is recommended on unstable defects of type **A-M2 (dints and impacts**), while the use of extra net is recommended in the presence of fissures associated to prominent arris.

The **removal / replacement of metallic elements damaged and plaster repair technique (R-C5)** consists on the volumetric expansion associated to its reactions upon the metallic elements corrosion, which can lead to the loss of adherence and dirt (rust), according to the depth of the fittings and the oxidation state of the metallic element. The removal or replacement of the metallic elements is a process that has to be analyzed individually, bearing the local conditions. The repair of the plaster depends on the defect and it can be done simply by cleaning (**R-A1**) or with a more invasive measure, such as **R-C1** technique **(entire or partial replacement of the IGP**).

The **localized reinforcement with staples of the IGP** (**R-C6**) is a technique used to repair unstable fissures. In what regards execution, this method can be resumed to the extraction of the inner gypsum plaster at about half of its density in stripes with 15 cm to each side of the fissure. Next, the surface is dried cleaned and the staples are placed in the center of the fissure´s axle, but with different sizes and alignment (so that line efforts are not introduced) and with spacing that diminishes with the proximity of the fissure´s edges. Afterwards, the fissure is fulfilled. Because this process is quite slow, fissures have to be isolated and orientated and they can't have wide extensions. If this doesn´t happen, this solution becomes extremely expensive before **R-C2 (net incorporation in the regulating coat of the IGP)** and **R-D1 (Local detachment of gypsum plaster)** techniques.

Local detachment of gypsum plaster (R-D1, Figure 5) is also a method used to repair unstable fissures caused by the movements of the support. This operation requires gypsum plaster´s extraction up to the support in stripes of 25 cm to each side of the fissure, then it´s fulfilled. Afterwards, gypsum plaster is disconnected from the support in the fissure´s area and a detachment ribbon is applied upon it. Next, gypsum plaster is installed back to its place with a reinforcement net added, which will have a fold in the area upon the fissure. This method is more efficient, although it is much more limited in terms of the setting field in what regards **R-C2** technique (**net incorporation in the regulating coat of the IGP)**, because it not only

increases the resistance to gypsum plaster´s traction, but also allows the distribution of induced effort by the support´s movement in a larger stripe of the cladding.

Figure 5: Local detachment of gypsum plaster and reinforcement with net (**R-D1**)

After having done the definition of the defects and its repair techniques, a **matrix with the defect´s co-relations and its repair techniques** was created **(Chart 3)**, which represents the level of adequacy of each repair technique to each defect. Each combination may have values, such as "0", "1" or "2", according to the existent relation between the repair technique and the inexistent, minor or major defect. The combinations that were initially produced based on the researched bibliography were later standardized / calibrated during the inspections, in order to validate the proposed system and the yellow proposals are the ones that underwent some changes.

5. VALIDATION OF THE SYSTEM AND STATISTIC TREATMENT OF COLLECTED DATA

The proposed classifying system for the repair techniques and the correlation matrix defect - repair techniques was validated through the creation of an inspection plan, which resulted in the check-up and examination of 23 buildings, in which 87 rooms had gypsum plaster. The collected data was later recorded in inspection and validation charts. The inspection charts point out not only the specific characteristics of a building, but also the rooms where the examined IGP are, including its conditions. The validation charts complete the inspection charts, in the sense that they record and describe not only the rooms´ defect (the walls are separated from the ceiling), but also the repair technique suitable for each defect.

Chart 3: The correlation matrix defect - repair techniques

A/R	R-A1	R-A2	R-B1	R-B2	R-C1	R-C2	R-C3	R-C4	R-C5	R-C6	R-D1
A-F1	2	0	0	0	0	0	0	0	0	0	0
A-F2	2	0	0	1	0	0	0	0	1	0	0
A-Q1	1	2	0	1	0	0	0	2	0	0	0
A-Q2	2	0	0	0	2	0	0	1	0	0	0
A-Q3.1	0	0	0	0	2	0	0	0	1	0	0
A-Q3.2	0	0	0	1	2	0	0	0	1	0	0
A-Q3.3	0	0	0	1	2	0	0	0	1	0	0
A-M1.1	0	0	0	2	1	0	0	0	0	0	0
A-M1.2	0	0	0	0	1	1	1	0	0	2	2
A-M1.3	0	0	1	1	1	1	1	0	1	0	1
A-M2	0	0	0	1	2	1	2	0	0	0	0
A-M3	0	0	0	0	2	1	0	0	1	0	0

Having diagnosed 331 defects and prescribed 437 repair techniques, there was an average of 1,3 repair technique by defect. As a result of all the work that was done on the field, one is led to conclude that the proposed repair techniques are authentic and important, in spite of the fact that the usage of some of them was not regular.

In order to validate the correlation matrix defect - repair techniques, it was necessary to determine the percentage of the cases in the sample in which a certain technique was associated to a certain defect. According to the available combinations that have already been presented, the adjustment is very good in all the cases presented with green, reasonable in all situations white colored and all the cases presented with red were considered poor, according to the following conditions:

- $2 < 17\%$; $0 > 33\%$;
- $17\% \leq 2 < 33\%$; $1 > 50\%$ ou $< 17\%$; $17\% < 0 \leq 33\%$
- $2 \geq 33\%$; $17\% \leq 1 \leq 50\%$; $0 \leq 17\%$.

After studying the results, one must conclude that the agreement was very good in 82% of the cases, reasonable in 14% and poor in just 4% of the sample. Due to these numbers, 5 items of the correlation matrix defect - repair techniques underwent some changes, which are presented in **Chart 3**, pointed out in yellow.
In what regards the statistic study, the examined facts are the following:

- percentage of defects diagnosed in walls and ceilings separately;
- geographical area of the examined buildings;
- rate of occurrence of each defect in global 87 IGP rooms;
- rate of occurrence of defects by areas of the affected surface (common area, border areas, prominent corner e recessed corner);
- rate of each repair technique chosen according to the inspections that were done ;
- rate of each repair technique chosen according to the kind of surface (wall or ceiling);
- rate of each repair technique chosen according to the area of the affected surface;
- absolute rate of each repair technique by each defect.

6. GENERAL CONCLUSIONS

The evolution of supports in the sense of having better flatness and un-warping conditions, associated to the growing needs of quickness in the work´s execution, led to the fact that the methods used to design and set plaster are out-dated in nowadays´ construction scenery. On the other hand, pre-dosed plasters based on gypsum and pre-dosed synthetic plaster arose, which are products totally prepared at the factory and are ready to be used (synthetic plaster). Water has to be added to the pre-dosed powder in order to make the pulp (pre-dosed gypsum plaster). These claddings have the advantage of having less density and being very fast and easy to apply. Actually, its setting can be done directly upon the support using only two coats, the first one to regulate and the second one to finish. Still, these claddings are exposed to humidity and their mechanical resistance is relatively low; therefore, these plasters must receive a colored finishing suitable to the areas and conditions to which they will be exposed, like impacts, friction, water and dirt. In this case, synthetic plaster has the advantage of being able to receive its finishing 48 hours after the application of the coat, whereas, in the case of gypsum plaster, it will take much longer, about 30 to 45 days.

IGP quality requires not only suitable project measures, but also its accurate application. Therefore, a premature occurrence can be avoided and consequently one can benefit from its economical profits.

Suitable building´s maintenance requires a pro-active predictive maintenance strategy, which is related to a maintenance plan. This means that in an early stage of the project, one must specify all the inspections that must be done to the building during its service life and, based on the reports that are written, decide the best solution. This strategy allows not only to sustain the quality levels, but also to reduce the global costs of the building.

The occurrence of defects as well as its repair is related to the phenomena that caused them, which will determine its steadiness or its development. Beyond being by itself a defect, humidity is the origin of the majority of the defects that appear upon plaster, especially the chemical ones. In fact, an efficient prevention can avoid the surfaces from getting humid, at least for long periods of time, and this can be achieved through a proper ventilation of the areas, good thermic isolations of exterior walls, suitable usage of the building or preventive solutions against the inner access of exterior humidity.

The repair techniques have changed, just like what happened to the plaster´s design and application methods. Nowadays, repairs are much more methodic, in order to promote a major adjustment of plasters.

The repair of a certain defect must be preceded by the elimination of its cause or causes. The defects presented on **§3** may not occur alone. In fact, when there are several defects in a certain area, the chosen repair solution must be able to repair all defects. Besides, the best repair solution has to be the one that respects both techniques and also economics.

As a result of the inspections done at the working field, one must conclude that the repair techniques are authentic and valid, because they were all used in the 331 defects that were diagnosed, in spite of the fact that the usage of some of them was not regular. The correlation matrix defect - repair techniques was validated and it revealed a very good adjustment in 82% of the cases and it was poor in only 4%. Still, 5 coefficients had to be changed.

The inspection charts are important tools for the inspection operations, because its usage leads to logical and objective reports. If these charts are associated to computerized tools, they will provide a much better management of the information for the inspector.

According to the statistic study, one may conclude:

- 70% of the defects occurred in walls and 30% in ceilings;
- 83% of the examined buildings are in Lisbon and are in average 18 years old;
- Physical defects are more frequent, having both 50% rate of occurrence (number of examined rooms). 68% of the examined rooms had humidity stains and it proves how plaster is exposed to the action of water and this rate also justifies the fact that humidity is responsible for a great part of the chemical defects;
- 55% of the defects happened in the surfaces, 30% in recesses, 12% in prominent corners and 3% in border areas;
- the technique that was more required was cleaning (**R-A1**), with 26% of choices; the second one was **R-C1** technique **(entire or partial replacement of the IGP**) with a rate of 18%; the techniques used upon the surface (**R-A**) and upon the finishing coat (**R-B**) of the IGP were 51% of the techniques, whereas the repair methods used upon IGP (**R-C**) and upon the cladding have the remaining 49%, which reveals the sample's balance in what regards the depth of the diagnosed defects;
- the rate of the repair techniques was always higher in the walls, which is related to the fact that 70% of the defects had been diagnosed in this kind of surface;
- 73% of the repair techniques were more frequently used in the common zones of the surfaces.

Having in consideration all the values that have been presented, one believes that the kind of collected data, as well as the extension of the inspection´s campaign, allowed to gauge, in a consistent manner, the classifying system of the repair techniques for IGP and the correlation matrix defect - repair techniques. Indeed, **Chart 4** presents the most common repair techniques for each kind of defect, which are also the most suitable.

Chart 4: The most frequent repair technique for each defect

Defect	A-F1	A-F2	A-Q1	A-Q2	A-Q3.1	A-Q3.2	A-Q3.3	A-M1.1	A-M1.2	A-M1.3	A-M2	A-M3
The most common repair technique	R-A1	R-A1	R-A2	R-C1	R-C1	R-C1	R-C1	R-B2	R-D1	R-B1	R-B2	R-C1