Introductory Report

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1. While all sorts of symposiums and conferences have been held the world over on the conservation of works of art and ancient buildings, this is the first time that, on the initiative of ICOMOS, an international meeting is being devoted to moisture and moisture alone. Our present meeting is an attempt to arrive at a synthesis - to leave aside all individual branches of study on the conservation of specific materials of which works of art are made (marble, brick, wood, metal, stucco, colouring agents, etc.) and try to find a common factor or origin in which the initial and indivisible cause of the damage may be diagnosed. True, it is essential for individual experts to make, for example, a thorough investigation into the problem of the degredation of marble, which is an enormous field still largely unexplored, and forms one branch of our "tree". Similarly, it is essential to arrive at complete knowledge of the life of moulds by cultivating them experimentally on a large scale in the laboratory, moulds being another important field. It is also necessary to use the microscope and research further into the diseases of bronze and other metals, which are a still further sector; and it is essential to complete stratigraphic research on paintings and frescoes, and chemical research on the degeneration of pigments and binders, for each particular branch of study is necessary and most useful.

But now for the first time we are going to look back a little and re-examine the conclusions already reached independently by each expert in his given field; each has observed that at the origin of almost all types of degeneration affecting individual materials is to be found one common factor - water. It is the presence of water which gives rise to the majority of the processes of decay, and water is the parent of all the organic and chemical processes which destroy monuments and works of art.

2. It is easy to declare, as I have just done in my summary, that water is the primary and common cause of a multitude of damage; however, when we try to put some order into our ideas we find that so much data and so many findings have been collected that - especially as work so far has been generally done in an empirical manner - the whole subject is in a state of chaos. The President and Honorary Officers of ICOMOS have set us the example of how to achieve clarity by dividing the subject-matter of this meeting into three main sections. As you know, Section A is devoted to information and is a survey, as it were, of the geographical areas affected by humidity. It will be something of a comparison of the causes and effects of humidity in the ancient buildings of the four main geographical areas - the tropics, the Mediterranean, continental regions proper, and desert regions. These are the four large climatic areas, differing widely from one another, rich in ancient human settlements - and therefore in ancient buildings - about which individual speakers are going to talk to you. Mr. Vunjak will be speaking on the Mediterranean area, Mr. Vos on the continental regions, Messrs. Kidder and Iskander on the desert regions and Mr. Fusey on the tropical ones.

3. Section B of the programme leaves geography aside and is composed of general information on remedial techniques. It will contain examples of all the present-day systems of combating moisture, with their advantages, their limitations and their inconveniences. This is the group of subjects which most excites all of us and most arouses our optimism or despondency, since each of us has past experience consisting in a personal record of tests and experiments involving a variety of methods and systems. And like any other past record, this will be a series of successes and steps forward, often alternating with disappointments and sudden halts.

Eminent speakers with great personal experience will be reporting to you on the individual subjects; Mr. Haller will be dealing with physical methods of drying walls such as making cuts or using siphons, Mr. Morary with electro-kinetic methods (i. e. electro-osmosis), Mr. Grunnau with physico-chemical methods such as transfusion or injection of various liquids into moist walls, and, finally, Mr. C. Anemona with the factors which encourage condensation and the techniques used to fight it. Thus, the first three speakers will deal with moisture rising through capillary action and the fourth with moisture from condensation.

4. The third section of the programme, Section C, deals with the question of instruments, and is therefore of interest to all of us alike; it covers methods and means for measuring moisture-content. The person who is going to talk to us about this is a past master of the subject, Mr. Paquet. Let me call your attention here to the paramount importance for us all of quantitative diagnosis, by which I mean measurement of the percentage of water ontained in the various points of a wall or floor.

5. What respect could one have for a physician who, while declaring that his patient had a raging fever, neglected to produce a thermometer and take his temperature? Yet the words "damp wall" and "damp atmosphere" are constantly used in connection with old buildings in the absence of any scale of reference, so that the adjective "damp" has come to apply to any walls or places containing water, whatever the amount. It is just as though we were content to notice that the patient was feverish without troubling about his actual temperature. Where this is the case the quantitative evaluation of the phenomenon - i. e. the seriousness of the damage - depends on the personal impression of the observer instead of being objectively expressed in figures as in the case of any precise technical problem. There are two measurements which it is essential to take scientifically, that of the relative humidity of the air and that of the percentage of water contained in the wall or floor, or - in the case of a cave or hypogeum - in the natural wall.

The second of these two measurements is by far the more important. We must never, in effect, judge the water-content of a wall by guesswork, on the basis of stains and erosion; these might be traces of damage due to some past phenomenon and need not signify the presence of moisture at the time of examination. A hall inside an ancient building may have dry walls though the air in it may be damp, in which case the negative result of an analysis of its walls will clearly reveal the presence of condensation. Determination of the water-content of a wall is thus essential in every case, even where, despite appearances to the contrary, no water is actually found to be present, or at least no serious amount. The "pathological percentage" is now universally considered to be any amount exceeding - however slightly - 3% by weight. This means that below this level, provided the room is aired, there is no danger to human health, or even to works of art, whether frescoes or marble of wooden objects, from moisture actually in the wall, though there may, under certain atmospheric conditions or at certain seasons, be damage due to condensation caused not by the state of the wall but by that of the air.

6. Naturally present-day instruments for direct measurement of moisture have each their particular field of use and their limitations. Some require gauging on a sample, and we know how hard it is to find one truly representative of the mass of different materials to be found in a wall; others are laboratory instruments and cannot be used in situ, while others still may give readings which will be influenced by the presence of voids or of metal inclusions. Yet we must accustom ourselves to a critical use of these new instruments about which Mr. Paquet is going to speak to us. I would stress, though, that we must not forget the traditional

method of determination by weight, which consists in weighing the moist sample as soon as it is dug out of the wall, drying it in a stove at 100° - 110°C, and weighing it again to see how much weight has been lost. This is still to-day the method most generally applicable and the one with the fewest limitations; its only defect is that it is slow. With the traditional gas or ordinary electric stoves still used in all analytical laboratories it takes from 7 to 9 hours to dry a sample of masonry, and this, I feel, is rather too long in the light of the present-day pace of things.

7. I am pleased to be able to tell the chemists, and others who may be interested in determining the water-content of a wall, of a recent innovation in this field, which provides a fairly adequate solution to the problem of accelerating the drying of samples of damp masonry and rapidly ascertaining the amount of moisture present.

Research on the possibilities of using a dielectric stove has been in progress since 1959; it has been done by the hygiene specialists Tizzano and Talenti, with my own collaboration, and with the financial aid of the Consiglio Nazionale delle Ricerche. With such a stove the physical process of removing the water contained in the sample is quite different from that involved in the case of a traditional gas or electric stove, where a current of hot air passes over the exposed surfaces of the sample and draws off the water by surface evaporation as it is brought out from inside by capillary action. This process is exactly the same as cooking, and drying is slow because the heat is exerted on the outside only and removal of all the water requires at least seven hours. In a dielectric stove, on the contrary, the sample is introduced into a high-frequency field (about 27 megahertz), and the heat is produced simultaneously inside and outside. Drying is rapid, requiring from a quarter of an hour to an hour in all. This innovation is little known as yet, which is why I take this opportunity of mentioning it. The apparatus - a small portable one - is commonly used in the plastics industry and is thus to be found on sale ready for use. Its power input is less than 1 KW on a 125 V standard voltage. The temperature inside the sample varies between 100 and 115°C and there is thus no danger that the calcium carbonate will be decomposed.

8. This dielectric stove was very useful to us in Florence when we wished to control, quickly and on the spot, the quantity of water retained in the walls and under the floor of the National Records Office, on the ground floor of the Uffizi, six months after the recent floods. It was urgent for us to know whether, after all the rooms had been subjected to a lengthy hot air treatment, the papers could finally be carried back to their places. In two days an enormous amount of measuring was done without even taking the samples to a laboratory. Each in its turn was dug out of the wall or floor, weighed, and placed straight in a dielectric stove in the room being tested. The speed with which the operation was thus effected meant that as each result was obtained it could immediately be made the basis for further investigation, so that the whole process could be interrupted where the quantity and distribution of the water present were known, or accelerated if the position appeared to remain obscure.

9. In any circumstances, and whatever the method adopted, each case of moisture in a monument must always be examined in terms of figures obtained by measurement of the percentage of water contained in each section of the building. This objective and impersonal procedure must become a habit for all experts and all administrations responsible for protecting the monuments of their nation, and an end must be made of the empirical methods of the so-called "practicians" if we are to achieve a system of diagnosis which is technically faultless. This is all the more necessary nowadays in that new commercial devices, inventions, and patented systems claimed to be effective against moisture rising by capillary action are being offered for sale more and more frequantly to the architects and the public bodies responsible for the protection of ancient buildings. Sometimes, unfortunately, the confidence of the public bodies which are persuaded to buy them is misplaced. It would be interesting to draw up statistics on the amounts spent to no purpose throughout the world on the reclamation of churches, historical residences and monuments in purchasing pseudo-scientific devices which have no effect, either good or bad. I venture to mention here a precaution of my own, which consists in officially determining the degree of moisture in the structure to be treated by having the appropriate samples tested for water-content in a State or university hygiene or chemical laboratory before accepting any new speciality, device, or patent invention offered commercially either for sale or for free trial. The same measurements must be repeated at the same points and at the same heights above floor-level at least a year, and preferably two years, after the treatment with the speciality or patent device has been completed, and the latter can be considered effective only if the water-content has distinctly decreased when the second set of samples is taken. Naturally all control measurements must be taken by the body responsible for the preservation of the monument and not be left to the author of the device it is intended to check.

This procedure provides the only valid means of making a provisional check on the effectiveness of the salvage work and puts the authorities in charge beyond the reach of criticism should the treatment fail; at the same time it makes it possible to experiment with due caution and to carry out scientific research in a field - that of moisture in old buildings - in which a great deal remains to be done.

10. We have now had a rapid glance at the way in which the subjectmatter of this meeting has been divided up, and have demonstrated the increasing importance, in view of the serious nature of our problem, of the practice of systematically determining the watercontent of the damp buildings to be protected. We will now examine the exact state of progress in connection with certain little-known techniques, and in certain sectors of research on particular problems connected with moisture where work has been done in Italy.

It is perhaps a not very well-known fact that a few years ago the Italian Consiglio Nazionale delle Ricerche set up a group to research into moisture in buildings, including both living premises and ancient monuments. This group is headed personally by Professor Gino Parolini, Head of the Engineering Faculty of Rome University, who has so kindly agreed to chair our meeting.

11. When Florence was so dramatically flooded last November it was most fortunate that this group was being directed by a man like Professor Parolini, who is not only a scientist but a man of action, and is able to arouse enthusiasm and elicit agreement, thus coordinating initiatives and available resources under a centralized leadership. You will already have heard of the bold way in which 250 or so pictures badly soaked in flood water were rescued after storage in the big "Limonaia", or conservatory, at the Pitti; in a few days of relentless work Professor Parolini miraculously succeeded in setting up an impressive hygrothermic system to condition the air in the Limonaia in such a way that the development of moulds and fungi was inhibited by the lowness of the temperature (which was about 10°C), while over-rapid drying of the wood backings was prevented owing to the high relative humidity of the air (90% to 85%). It had in fact been feared that unhampered drying would separate the underneath coat from the backing, but the salvage work turned out to be perfect. By constant control of both temperature and humidity the paint was prevented from cracking off, and as the pictures dried it was possible to transfer them to the big restoration laboratory set up in the meantime by the Florentine Soprintendenza alle Gallerie in the former Abbasso Fortress. This is a laboratory which truly deserves a visit, owing to the splendid and extremely rational way in which it has been arranged and equipped and the example of civil cooperation set there by restorers from all the civilised nations.

12. For the flood-damaged frescoes the danger was doubly great. While there was a risk that mould might form on them if evaporation of the water in the walls were not accelerated, there was a further risk that if this evaporation took place too early on the frescoed side the colours might be damaged by crystallization of the salts dissolved in the water

The Florentine Soprintendenza alle Gallerie therefore adopted a system of "elastic defence", in some cases removing the fresco from its backing and transferring it elsewhere, and in others gradually drying the wall while leaving it on. Special mention is due to the help provided by our German friends in connection with the drying; they supplied us with a large quantity of butane burners with a naked flame which produced a stream of warm air found to be highly effective as a means of hastening the evaporation of the water in the walls in mid-winter. Drying was always done from the back, or in the skirting board at least two metres below the fresco, so as to force the salts off the frescoed surface to non-frescoed areas where they could cyrstallize without doing any harm. Naturally warm-air drying is suitable only in the case of walls damaged by flood-water, since these contain only a limited quantity of moisture and penetration has been accidental; it is quite the wrong method where the supply is inexhaustible, as in the case of dampness rising from the ground, where adopting it would be like trying to use pumps to empty a lagoon communicating directly with the sea.

13. I would like to come back here to the general problem of moisture rising from the ground by capillary action, which attacks and damages so many monuments the world over, and give a short account of an experimental operation carried out by the C.N.R. research group in Rome in 1966. The purpose of the experiment - which was carried out by arrangement between the C.N.R. and the Direzione Generale delle Antichità ed Arti - was to dry out a small Eighteenth-Century church suffering from moisture rising from a source which could not be removed, to a height of over four metres. This was the church of Santa Maria delle Neve in the Via del Colosseo.

The system adopted was merely an up-to-date version of the traditional one in which a thin sheet of lead is inserted into the moist wall. The method - which will be familiar - consists in successively making a few holes by hand with the aid of a chisel, no single hole being opened until the preceding one has been filled up with new masonry under which a thin sheet of lead as broad as the wall is thick has been laid horizontally. This traditional system, though efficient, is a slow one, since the fresh mortar must be allowed to harden. Further, the chisel blows may cause the plaster backing of the frescoes to come away from the wall, and, in addition, the method cannot be used for walls thicker than 75 centimetres, since in such cases the workmen could not do the job without destroying too much of the wall.

Modern technical progress has enabled the system to be brought up to date and accelerated. A rotary machine does the cutting, thus doing away with the shocks caused by the chisel blows, and a waterproof resin is used instead of the sheet of lead; the width of the cut is thus reduced to 3.5 cm, whatever the thickness of the wall. The machine, driven by a 1 HP electric motor, is of the type commonly known as a "core-drill", and used for the purpose of removing cylindrical samples from rocks. In the present case its axis is positioned horizontally, so as to produce a fissure in the wall by drilling several holes adjacent to one another. With such a machine it has been found easy to make holes through walls over a metre and a half thick, which would have been impossible by the traditional hand method. The second innovation - i.e. the substitution of the polyester resin for the sheet of lead - is a considerable advantage from the point of view of stability, owing to the plasticity of the new material, which is introduced into the fissure in a liquid state and fills it up to the top; it hardens in three hours and can then bear the weight of the whole building with no risk of settling. The work is eight times more rapid than when the traditional method is used, as there is now no need to wait over a day to be sure the mortar has sufficiently hardened between the bricks.

The experiment, which was financed by the Consiglio Nazionale delle Ricerche, was extremely successful. The total cost was about six million lire, and the unit cost about 160,000 lire per horizontal square metre of wall treated, but it is believed that this figure could actually be reduced by about a quarter. A check is now to be made to see how long it will take for the part of the wall above the resin layer to dry out completely. At the end of the job, in December 1966, two groups of samples were taken, on two different vertical lines, at points inside the wall, and the moisture-content at given heights above floor-level was thus determined. Similar samples are to be taken three years running (January 1968, January 1969 and January 1970) for determination of the residual moisture-content, so that the drying process may be followed up; they will always be taken from the same areas and at the same heights.

Where only one fresco is affected it is proposed to make a U-shaped cut around it, as shown in the drawing of the proposed scheme for Botticelli's fresco of St. Augustin in the church of Ognissanti in Florence, the lower portion of which had already, even before the floods, been affected by moisture rising from the ground.

The above experiment, and the possibilities it opens up of obviating the need to remove the frescoes from the walls, were described last September at the Museum Climatology Congress in London, in a report prepared by Paolo Mora and myself. It is thought that the curting operation, once completed, should be followed by measures of some sort to accelerate the drying from the back of the part of the wall above the cut, which otherwise would, in certain climates, take several years to lose all the water stored up inside it; such, for example, is the case in Venice.

Not the least advantage of rapid machine cutting as opposed to the traditional chisel method is, as we said earlier on, that it can be used on any wall thickness. To-day, for example, if the Italian authorities so wished, a study could be made of a means of permanently saving Raphael's fresco of the Sibyls in the church of Santa Maria della Pace here in Rome, which is giving such cause for anxiety. There would be no problem at all involved if the machine method were adopted for the enormous pillar some three metres thick which bears the wonderful fresco, and which is absolutely soaking.

An operation of this type would even yesterday have been quite unthinkable, but to-day we have a safe alternative to the removal of the frescoes from their place on the wall.

14. If I have not by now exhausted the patience of my hearers I would like, as my conclusion, to give some news of the recent investigations carried out in two dàmp churches in Venice, in May and June of this year. The initiative was due to Giorgio Torraca, scientific adviser to the International Centre for the Study of the Preservation and Restoration of Cultural Property, whose Director is Professor Plenderleith. The monuments of Venice are, generally known to have been attacked by humidity both outside and inside, involving two fields of necessary action which are quite distinct and must be considered separately, since the forces at work in the two cases and the phenomena involved are completely unlike.

To avoid any dispersal of effort, the study undertaken by the Rome International Centre was confined to the insides of the churches, where the volume of air is limited and it is easier to check hygrothermic phenomena by direct scientific measurement. On the advice of the Soprintendenza alle Gallerie ed ai Monumenti, two churches were chosen which provided typical examples of damage due to moisture; one of these was San Sebastiano, famous for its Veronese frescoes, and also for Veronese's tomb, and the other was Santa Teresa, which, though it has no frescoes, is of interest owing to the state of its marble decoration, which is now very badly damaged indeed. The study was made exclusively on the basis of measurements taken with instruments, i.e.: -

a) Relative humidity and temperature of the air, both inside and outside the church.
b) Surface temperature of the inside walls and the floors.
c) Moisture-content of the walls and the area under the floors.

The instruments used were those belonging to the Moisture Study Group set up under the Consiglio Nazionale delle Ricerche, and included the dielectric quick-drying stove I spoke of earlier on, which served to dry the samples. All portable equipment was selected with a view to obtaining immediate readings which could be immediately discussed by the group, so that work went on at the tense pace required for good and exciting team-work which could resist the physical strain of such continuous and concentrated efforts. The surface temperatures of the masonry, which were as fundamental a factor in the investigation as determination of its moisture-content, were taken with a Siemens instant thermometer with a converging lens designed to catch the infra-red rays given off by the surface being examined.

The readings obtained showed that the damage occurring inside the churches in Venice is not the result of some vague, enigmatic and inescapable phenomenon in the prevailing physical and climatic conditions, which the empiricists have christened "saltiness", and which has been so much talked of in Venice that it has become a commonplace. The internal damage is the result of two phenomena only, and they can be exactly defined and measured; these are the rising of moisture from foundations immersed in water, by the much-talked-of capillary action, and the condensation of water from the air, both of which exert a large-scale action in Venice. We found when measuring that there was a "pathological" degree of rising moisture to a height of four metres (a condition practically never encountred inland), while condensation occurred to a spectacular extent, owing to the excessively high relative humidity of the air. (The yearly average in Venice is 74%, which is the highest in Italy if we except Pavia, with 79%. The gravity of this climatic factor will be seen if we compare the average relative humidity figures for January of three Italian coast towns - Genoa (58%), Trieste (65%), and Venice (81%)). A peculiar consequence of the condensation is that it prevents the damp walls from being dried out.

15. We all know that treatment by evaporation of walls suffering from rising moisture causes surface cooling. The readings obtained in San Sebastiano showed that the damp walls were from 1/2° to 1°C cooler than the dry ones. It is also evident that, owing to the high relative humidity of the air in Venice, condensation will primarily occur on the cooler surfaces such as plasters from which moisture is evaporating, or marble. This would explain the strange fact pointed out to us by the Soprintendente in Venice: a wall of the church of San Sebastiano which had been cut horizontally and had lead sheets inserted showed immediate and very temporary improvement as a result of replastering but was now, three years later, newly disfigured by large patches of damp. We carefully examined the wall in question and found that measurement of the moisture-content above and below the lead sheet showed that the cutting operation had in fact been effective, since while the reading for the area below the cut was still 20% it had been halved to 10% above; yet the partial drying obtained after three years had been excessively slow. If this is the general rate it will take from 9 to 11 years to dry the wall of a building in Venice by the horizontal cutting method, whether in the traditional way by hand or in the modern way using a polyester resin and cutting by machine. The reason for this slowness is that the drying is counteracted by the opposite phenomenon of the depositing of moisture on the surface by condensation.

The investigation carried out has thus clearly shown that while the cutting treatment is perfectly effective the problem of the wall's "convalescence" is an extremely serious one in Venice. From now on in every case the cutting treatment should be followed by a further treatment to accelerate evaporation of the water previously absorbed, such, for example, as heating from behind or surface ventilation, or some other system; the method and means will require to be devised by specialists to suit each set of conditions. It is believed that the period of "convalescence" for Venice can be reduced from 9 to 2 years.

In Santa Teresa, which was the other church examined, and which, as we said, has no frescoes but is lined with marble now very much spoiled and sadly decayed and crumbled, we found that in May and up to 21st June condensation was occurring to a serious degree. Unlike plaster, marble does not absorb moisture from condensation, which therefore remains visible, and the cloths on the marble altars were dripping as though they had been immersed in a bowl of water. A rapid survey of the mean ambient temperatures in Venice had led us to the provisional conclusion that in Santa Teresa condensation affects the marble for eight months of the year. Whereas there has been energetic action to combat the rising moisture by the lead sheet method, nothing has ever been done about such condensation.

17. The results of the measuring operations have led us to the conclusion that the time has come for a change in basic policy regarding the interior protection of ancient buildings in Venice. The problem must now be taken as an indivisible whole, and the physical fact accepted that all damage, whether to frescoes, pictures, or marble or wood carvings, has its origin in the same cause, i.e. the dampness of the building. It is possible to-day, by applying a systematic methodology in the sphere of moisture-determination, to discover exactly which types of moisture are present and so draw up a "hygrothermic diagnosis" sheet for each historic building. The treatment subsequently carried out in accordance with the data given on this sheet - which must show exactly how the moisture is distributed through the walls of the whole building - must begin with horizontal machine-cutting of the damp masonry. The second stage will be treatment of the air, by a process which will provide both for rapid drying of the walls after cutting and

for the initial combating of condensation. What is involved, in short, is a system for heating the air and conveying it over the cold surfaces in the building, while using the smallest possible volume of air. This treatment must be applied on an industrial scale, using a limited power supply and automatic devices which will connect or disconnect the air distribution system both night and day, so that the hot air stream is applied only for the minimum period sufficing to prevent condensation. Various techniques may be adopted for producing a hot air stream passing over the marble or wall surfaces (by a system similar to that adopted for car windscreens), or for producing radiant heat, or slightly heating the edges of the floors along the bottom of the walls, etc. etc. In this context we are actually dealing with a completely new type of treatment, and research on it will be required by engineers who have fully assimilated the problem as a new one in its particular application to the restoration of monuments. On this basis, and to preclude any waste of time, we have drawn up a programme of immediate and subsequent research and of experiments to be carried out in Venice in 1968 in the two above-mentioned churches, and in a third - San Nicolo dei Mendicoli - likewise badly damaged by moisture.

I trust that when we meet again - which I hope will be in a couple of years at a second ICOMOS meeting on moisture in monuments - I shall be able to tell you about the results of this new programme of experiments, which, as I have said, should give a new and single orientation to the work of conserving the interiors of the monuments of Venice, based primarilly on a judicious use of heat.