NOTES ON EFFLORESCENCE ON BUILDINGS AND STRUCTURES, TOGETHER WITH THE MEANS OF COMBATTING IT.

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PRELIMINARY.

Efflorescence on Buildings

Trouble due to efflorescence on buildings of all kinds is not an uncommon thing in the Punjab and Northern India, and if the evil can be cured by improvement in the manufacture of materials, or counteracted, once it has appeared, by taking special precautions or adopting preventive measures, we shall be practising true economy by reducing the annual expenses of maintenance. The facts narrated in this paper are based on experience of a dwelling house in Lahore, where the experiments have now been carried on at intervals over a period of twelve months.

The house stands well, in that it has a plinth of about two feet, while the surrounding compound is well-drained. The walls are of considerable thickness; the house was built some forty years ago and the bricks vary in size from the old fashioned Lahore brick two inches or so in thickness, to the ordinary brick $9'' \times 4\frac{1}{2}'' \times 3''$. The proportion of mortar used was liberal, and the thickness of the plaster on the walls and floors varied from $\frac{3}{4}''$ to $1\frac{3}{4}''$. This great thickness of plaster made the application of remedial measures a task of some difficulty, owing to the liability to crack; and extraordinary care had to be taken in applying new plaster. The floors of one or two of the rooms which gave further trouble last rains were recently taken up in places, and it was found that there was no concrete under the bricks, which had been laid flat on the earth filling.

The house was put into thorough order during the autumn of 1913, when the old plaster was removed from the floors as well as from the walls to a height of five to six feet, and was replaced by fresh plaster of kunkar lime and sand, except in the drawing room, where the new wall plaster was of cement and sand, as it was intended to paper this room, and the efflorescence had been strongly marked.

During the rains of 1914, which were fairly heavy in Lahore, it became evident that the repairs of the previous autumn had not improved matters, particularly in the drawing room, where the wall paper was ruined, and large brown patches appeared over the greater part of the area which had been treated with cement. In this room the floor also gave such trouble, that eventually it was found necessary to remove carpets and drugget, and as after every heavy shower of rain there were patches of moisture almost amounting to pools, the room was perforce abandoned for the time being.

The author was asked to remedy this undesirable state of affairs in October 1914, and after the winter and spring rains further remedial measures in certain parts of the house were tried in April 1915. These again were partly successful, and the weak spots disclosed have recently been treated in other ways, which are now to be described.

It will be understood that the work carried out has been experimental, less drastic methods being tried first to save expense, if possible, and the more radical measures being only adopted when the first had failed.

It is evident that, if the disintegration due to the efflorescence so commonly seen on the surface of structures of all kinds is to be successfully combatted, we must obtain full knowledge of its composition by chemical analysis, and this again entails analysis of the brick clay and the constituents of the mortar used.

The clay from which bricks are made in the neighbourhood of Lahore contains potassium nitrate, soda, magnesium salts, and other impurities. Owing to the fact that bricks are generally burnt at too low a temperature, and that there is a slight deficiency of silica in the clay, the brickwork develops efflorescence which has a destructive action on bricks and plaster. The object of the experiments now to be described was to counteract this destructive action.

TREATMENT OF POINTED SURFACES.

The brickwork in the plinth and floors of the verandahs (which were unplastered) was washed with dilute hydrochloric acid (1 to 3)—three coats being applied over the whole surface—but before applying the wash all joints were pointed with a mortar, made of two and a half parts by volume of freshly slaked stone lime, two and a half parts of well washed dry sand, and one and a half parts of boiled linseed oil, prepared as stated below. This work was done in October 1914, and up to the present time (November 1915), there are no traces of efflorescence, nor have the bricks disintegrated. The pointing, too, is very hard, and as good as the day it was put in.

Washing the bricks leaves a thin film consisting of chlorides of various sorts, including magnesium chloride. As fresh efflorescence reaches the surface, the magnesium oxide carried with it combines with the magnesium chloride already formed, and an oxychloride cement is produced as a thin film on the surface, as well as to some depth in the capillaries of the bricks, thus preventing the action of moisture and the rising of fresh salt to the surface.

The mortar used in pointing was a lime soap mixture, *i. e.* slaked lime and free oil, resulting in a reaction taking place between the efflorescing salts and the lime soap, when corresponding salts of lime were produced, and the salts converted into soap.

As the potassium and sodium salts in bricks are converted into caustic alkalis in the process of burning, they would at once form soaps on applying the mortar, a proportionate part of the soap lime being converted into caustic lime, which, again, is slaked by the free water in the mortar before it has set. The free oil protects the work from atmospheric moisture, and prevents further capillary action in the brick.

TREATMENT OF PLASTERED SURFACES.

Preparation of the plaster.

The sand must be washed and very thoroughly dried before being mixed with the requisite quantity of freshly slaked lime. After thorough mixing, boiled linseed oil is added, and the compound again well mixed before being put into a pan on the fire for twenty minutes, by the end of which time the mixture should be on the point of boiling, and of a consistency suitable for spreading. During this process the fire should not be too fierce, and the mixture should be constantly turned over with a trowel so as to ensure the gradual absorption of the oil by the lime and to prevent any portion sticking to the bottom of the pan.

The Drawing Room Floor.

In the drawing room floor, the original state of which has already been described, the method adopted consisted in removing all old lime and plaster (the latter about $\frac{3}{4}$" thick), raking out and cleaning all joints in the brickwork, and pointing with a mortar of lime, sand, and linseed oil. After the pointing was completed, a plaster $\frac{1}{4}$" thick, made of lamp black, sand, and cotton-seed oil, was applied in the ordinary way, the surface being worked smooth with floats. The plaster was made by adding five parts of lamp black and seven parts of cotton-seed oil to thirty parts of dry, screened and washed sand. These ingredients, having been well mixed, were put in a pan, and placed on a fire for forty minutes, care being taken to stir the mass continually whilst it was being heated, and that an even heat was applied—the temperature being about 280° F.

This has been found to be very effective, forming a hard slate like surface, and since it has been laid the former trouble has entirely vanished. The probable action is principally, if not entirely, mechanical, the oil and lamp black filling the capillary pores in the bricks, thus preventing salts and moisture from rising to the surface. Over this was laid another coat of plaster similar in composition to the mortar used for pointing the brick.

The Drawing Room Walls.

To remedy the trouble on the drawing room walls, the plaster was entirely removed to a height of six feet from the floor, whilst all the joints in the brickwork were also raked out to a depth of half an inch. The walls thus exposed were washed with a solution of gum shellac and soda crystals, composed of two pounds of soda crystals, and seven pounds of gum shellac to twelve gallons of water, which was heated in a pan over a fire, but not allowed to boil. The solution, when ready, must be kept in a well closed can. When applied as a final outer coating, one gallon of this solution is mixed with one gallon of any ordinary paint and applied as such, but in the case of the drawing room walls the mixture was applied without any paint.

The probable action consists of an entirely mechanical closing of the capillary pores—thus preventing the formation of efflorescence on the surface—the soda forming a solvent for the shellac.

The brickwork thus having been protected, plaster was applied in thicknesses of half an inch at a time, each layer being thoroughly beaten in the usual way.

This plaster was composed of 42 lbs of ordinary rosin, $2\frac{1}{2}$ gallons of raw linseed oil, 10 lbs of paraffin wax and 38 lbs of freshly slaked lime, mixed and boiled for fifteen minutes before being applied. After it had thoroughly set, *i.e.* in about four days, the surfaces were faced with a coating of burnt gypsum (calcium sulphate) and fresh slaked lime in the proportion of three parts of lime to one of gypsum and it is of importance that this plaster should not set too quickly. To ensure slow setting, the surface should be brushed over with a weak solution of citric acid (1 to 9). The surface will sweat for at least five days, and the damp as it appears should be removed with pads of muslin or some soft substance. When the plaster is qute dry a highly polished surface can be produced by rubbing it with powdered pumice.

Artificial Rubber Solution.

In dealing with the floors of four other rooms, it was decided, for the sake of economy, to apply the plaster of rozin, raw linseed oil, paraffin wax, and slaked lime, for a width of twelve inches from the walls, and over the whole floor surface of the room to try an "artificial rubber" solution, which the author had used in many other cases with complete success.

The recipe is as follows :—

2 lbs boiled linseed oil.

1 lb cotton seed oil.

2 lbs petroleum.

2 lbs raw turpentine.

2 lbs sulphur.

These ingredients should be mixed in a can, and must be boiled for two hours. Owing to the inflammable nature of the contents, care must be taken to use a can which will hold at least eight times the quantity to be boiled. The mixture as it approaches boiling point rises very rapidly in the vessel, hence the necessity for this precaution. When ready, the mixture should be applied as a paint.

While there are no signs of damp or efflorescence on the width of twelve inches next the walls, the rubber solution on the rest of the floors has been destroyed, and the efflorescence is as bad as before. It is evident, therefore, that the rubber solution does not prevent the moisture from penetrating, and the floors have since been treated in a manner similar to the drawing room floor, the whole of the existing plaster being removed.

Dados.

All the walls to a height of six feet from floor level were rendered with a plaster of rosin, raw linseed oil, etc., similar to that used in the drawing room, and were finally finished with a wash of different colours. The basic wash is of stone lime, which must be slaked with boiling water in a covered vessel, to retain all vapours. When ready, six quarts of the slaked lime are passed through a very fine sieve, and to this is added one quart of rock salt and one gallon of water. The mixture must then be boiled and skimmed. To every five gallons thus prepared is added, by slow degrees, one pound of powdered alum and half a pound of copperas (sulphate of iron), also three-quarters of a pound of potash; to this any colour can be added.

The object in keeping the vessel covered is to prevent any lowering of temperature which would check the slaking of the lime and thus weaken the product. It also prevents the loss of a considerable quantity of finely divided lime, which would otherwise be carried away by the vapour. Nearly every lime contains an appreciable quantity of magnesia. The addition of sodium chloride (rock salt) causes the gradual formation of magnesium oxychloride, and possibly other oxychlorides, which greatly strengthen and harden the wash. The addition of powdered alum causes a precipitation of gelatinous alumina, and this precipitate is subsequently partly or wholly dissolved by the addition of potash forming a glutinous "size." The addition of copperas is chiefly for the purpose of putting colour into the wash. It is also probable, however, that some chemical action is evolved—the alum and copperas parting with a portion of their sulphates and combining with the lime to form sulphate of lime, which, it is known, improves lime plaster and washes, and protects them from the destructive action of outside agency.

Alternative Treatment.

In one small room which was in a very bad condition, both as to the floor and the walls, a slightly different method was adopted. The old plaster on the walls was not removed, but was entirely rubbed down from ceiling to floor with wire brushes so as to get rid of all decayed plaster. A wash of green vitriol (sulphate of iron)—one part of green vitriol dissolved in three parts of water—was then applied to the surface in two coats, with twenty-four hours between each application. Forty-eight hours after the second coat had been given, two coats of the artificial rubber solution were applied, and the room was finally treated with the same colour wash as the other rooms.

The floor was of brick laid flat. All joints were raked out and two coats of vitriol solution were applied, after which two coats of the rubber solution were used. This treatment has been entirely successful, and there are no signs of damp or efflorescence. In considering the probable action of the green vitriol wash on the brick floor, the author is of opinion that the caustic salts, onmeeting the solution, are converted into sulphates, and a film of hydrated oxide of iron is formed. This film evidently acts as a protective coating, and prevents further capillary action.

With regard to the lime plaster on the walls, the author is of opinion that sulphate of lime is formed, with a protective coating of hydrate of iron.

Further experiments are being made with a wash of ammonium carbonate to be applied to lime plasters immediately after the plaster starts setting. The solution of carbonate hastens the conversion of the plaster into carbonate of lime, which is the natural hardening process, and thus renders it more quickly impervious to destructive agencies.

PREVENTIVE MEASURES IN NEW BUILDINGS.

The following notes may be of use to anyone deciding to apply the remedies herein discussed to new buildings during the course of construction :—

On completion of the concrete in the foundation, a half inch layer of lime soap plaster should be spread over the top surface. While this plaster is fresh a layer of brickwork should be laid on it, care being taken to see that the bricks are fairly dry so as to ensure cohesion. When the walls reach floor level, a layer of concrete should be spread over the whole area of the building to form the floor, the idea being to have a continuous floor, without breaks at every dividing wall, as any joint which cracks may later prove a source of trouble. The concrete should be about four inches thick. Over this lime soap plaster should be spread to a thickness of about half an inch. If it is intended to have a brick floor, then the plaster should be spread over the bricks, care being first taken to thoroughly rake out all the joints. The final plaster of lime soap can be laid on walls and floor at one and the same time. Before fixing the door and window *chowkats*, the sides of the openings should be plastered with lime soap, taking care to rake out all joints in the brickwork before applying the plaster.

All the walls for a height of about four feet should have the joints well raked out and pointed with lime soap mortar, and when this has set, they should be washed with a solution of hydrochloric acid or sulphate of iron. About half an inch of the lime soap plaster can then be applied to the height treated. Great care must be taken when joining on the ordinary lime plaster to the lime soap plaster—an overlap of about three inches is advisable to avoid the possibility of a crack developing.

BRICKS.

The author has hitherto been chiefly considering the case of a building already in existence, but it would obviously be better, if possible, to do away with the presence of deleterious salts in the brick itself, and with that object in view he would offer the following remarks :—

Among all the phenomena giving rise to the imperfect products, which makes the manufacture of a good brick difficult, the most troublesome are the salt like efflorescences so hard to remove even when present in very small quantities. They are found chiefly in places promoting rapid evaporation, that is on the corners and edges of walls. They make the manufacture of a weather resisting brick more difficult and uncertain, since they cannot be detected by the unaided eye before burning, and only become visible later on, especially in the case of clays which are not highly coloured in their raw condition. Not only does the water which is used for the softening of brick clay contain, without exception, a varying quantity of mineral constituents in solution, but the clay itself has the power to retain substances soluble in water, which are formed by the never ending decomposition in the brick clay, and the more plastic a clay is the more will it retain. If the clay has been allowed to weather during the winter, further opportunity is afforded for the formation of additional soluble salts, especially when iron sulphate is present as well as potash, soda, magnesium salts, carbonate of lime, or calcium sulphate. The removal of these salts is not affected to any appreciable extent by atmospheric precipitates (though this is presumed by many) because the moistening of clay makes it impervious, preventing "leaching" of any kind, and, secondly, because the process of formation of the salt goes on for years.

The formation is specially facilitated by the exposure of clay in cold weather, and becomes most energetic when the clay has been brought to a workable condition suitable for manufacture. The removal of the soluble salts formed in the winter or during the rains, by washing, can therefore be only very superficial, and other industries have shown the impossibility of removing, even approximately, soluble compounds from substances possessing physical properties similar to clay. The effect of soluble salts becomes the more deleterious since the process of formation goes on during the working of the clay and the drying of the bricks. Such what is saline clays have also a special tendency to give rise in the kiln (during technically called the "water smoking process," which invariably starts in the first seven lines of bricks ahead of the firing lines) to salt like efflorescences. Since the evaporation of the water on drying can take place only at the surface, or to a very slight depth in the case of sandy or porous clays, all the moisture must first be taken to the surface by capillary attraction, before it can be evaporated, and thus the salts taken into solution are brought to the surface, where they remain. The denser the solution of the salts, the closer to the surface will they be deposited. The salts thus segregated, after the removal of the water, form a dusty coating of crystals of microscopic size, which are very difficult to observe with the eye, especially when their colour is similar to that of the clay, because they enclose a clayey substance within their aggregations.

Such salts are by no means easy to remove either mechanically or chemically. Mechanical means may be employed in the case of efflorescence or discolorations which do not adhere very firmly, but chemical means imply an exact knowledge of the chemical composition of the deleterious salts, which are at times visible after burning—being usually of a greyish colour—but they are then firmly burnt into the brick.

Owing to the slight consideration which has hitherto been given to the soluble salts contained in brick clay, probably due to their volume being so small, the chemical composition of this part of the clay has never received proper attention, though it is of great importance, inasmuch as it is only by the application of such knowledge that the salts can either be converted into soluble and harmless compounds, or decomposed in the process of burning.

Careful examination has shown that the soluble salts contained in bricks are concentrated on the surface, The author had two samples of clay from the vicinities of existing kilns in Lahore treated, and sent for analysis ; one was a grey, and the other a blackish clay. After exposure to the air for some time in the raw condition, both showed a distinct salt like efflorescence on the corners and edges of the lumps.

In order to determine the nature of this efflorescence a quantity of the clay was boiled in distilled water, and, after settling, the perfectly clear liquid was evaporated to dryness, and the salts obtained sent for analysis. The salt obtained from the grey coloured clay was crystalline, darkened by organic matter, and was slightly deliquescent—that obtained from the blackish clay was yellowish green, extremely hygroscopic, deliquescing in a short time to a syrup like fluid in the presence of moisture. The composition of these salts was found to be, in the first case, lime, potash, magnesium, ferric oxide salts, and alumina, and in the other, calcium sulphate, potash, soda, lime, magnesium, iron sulphate and alumina.

It is thus seen that all the salts in the grey clay possess a decided tendency to crystallize, and we might therefore expect that in a brick made from this clay there would be an undesirable tendency to produce efflorescence, with consequent injury to the brickwork. In the darker coloured clay the deliquescent salts of iron and alumina predominate. These crystallize themselves with difficulty, while they interfere with the crystallization of other salts, and are thus less injurious.

The samples analysed, however, were returned together with fresh samples for further investigation, as the author did not feel quite satisfied with the results of the first analysis.

All the salts can be decomposed by burning at a temperature of about 700° F ; and, when decomposed, they will combine with the silica in the clay to form a compound solution of lime and the different alkalis.

The author would suggest that chemical cones (Segers for preference) be used for testing the degree of heat in the kiln, as, with these cones, a registered temperature can be kept in each chamber of a continuous kiln, and thus the decomposition of soluble salts present in the clay can be ensured during the process of brick burning.

DISCUSSION.

ıR. WAITE, in introducing his paper, remarked that he othing further to add, but would be glad to listen to any ms that might be offered.

.MR. RODGERS asked what had been the cost per hundred re feet of the lime soap plaster.

LALA WAZIR CHAND CHOPRA said that he had found ıdlo cement plaster very effective on the floor of the canal house at Mast Chak, about twenty miles from Lahore, where Ravi in flood flowed round the compound. The cost was v Rs. 6 to 7 a hundred square feet. He had found two ses of half inch slates laid in cement mortar in the walls loor level an efficient damp proof course in two other ılows in his Division, but the cost had worked out to 35 to 40 per hundred square feet. It would be interest- know what had lead the author to try so many different

'R. HARFORD considered it was premature to judge of ıcy of Mr. Waite's experiments. The season follow- experiments had been one of the driest known for many ıd it would be interesting to know, after the lapse of ıtly long period of time, if the effects of the treatment ...re still considered satisfactory. He was inclined to think that during a very wet season the floors and walls would begin to sweat. He had carried out many experiments in water proofing, but had given it up as almost hopeless. The only thing was to take up the flooring, put in a layer of dry cinders, and then excavate all round the building for a depth of one foot, and fill up with dry ashes. The great thing was to keep the damp out, and efflorescence would stop. There were several buildings in Lahore within 80 to 90 feet of the canal distributary with their floors nearly two feet below water level, and it had been impossible to live in them, till the floors had been taken up, and treated in this way.

MR. B. H. WILSDON, PROFESSOR OF CHEMISTRY, GOVERNMENT COLLEGE, Lahore, pointed out that the mechanism by which water containing alkaline salts from the soil rose in brick work was that known as capillary attraction. The height to which liquid would rise in the capillaries of brick work was determined by the average size of the pores, the temperature, and the nature of the aqueous solutions which constituted the liquid ; but it is not generally recognised that the actual height on brick work at which salts crystallised did not represent the true capillary height, but the equ. point at which the rates of diffusion of the liquid and the evaporation from the brick surface balanced. By measurii average pore diameter of brick it was estimated that water be capable of rising to a height approaching twenty feet. estimate was arrived at by measuring the force required to water out of the capillaries of a section of brick ; the fo required being obviously equal to the hydrostatic pressure of column of liquid the capillaries were able to support. phenomenon could be demonstrated simply by suspending a s.. of blotting paper in a coloured liquid. If the diffusion was allow to take place in air, a well defined point would be observed which the dye dissolved, and beyond which the water did rise. If the strip was suspended in an atmosphere in w evaporation could not take place, the water would rise more and no such limiting height would be noticed.

The conclusions to be drawn from this were that mec! closing of the brick pores on the surface, by preventing e tion, would only result in raising the level at which efflo occurred, unless treatment was given to a considerably great than had been done in practice. The obvious remedy efficient damp proof course. Bricks of a large pore would serve the same purpose by limiting the capillary ris..

As regards the corrosion of bricks there was no evidence that the action was other than physical. Moreover an inspection of the face of any building, exposed to rain, would show that corrosion took place in bricks far above the height at which efflorescence occurred. It was suggested that besides the disintegration due to the crystallisation of salts carried by diffusing water in the pores of bricks, corrosion might be due to the action of rain water on bricks which contained alkali derived from the clay of which they were made. Experiments showed that bricks made from clay to which varying amounts of salt had been added exhibited this phenomenon. Those containing from three to four per cent. of an artificial *reh* mixture, on being placed in pure water, showed considerable corrosion in a short time, while the "pure" brick was unaffected. Moreover a pure brick placed in a concentrated solution of salts was unaffected. The conclusion drawn was that the alkali contents of the clay, from which a brick was made, was an important factor in determining its resistence to corrosion.

MR. DORMAN asked if he was correct in thinking that disintegration did not take place below ground. He had more

ıce dug down to the foundations of disintegrated walls
ↄ always found the bricks below ground in perfect preser-
. He had experimented with Mr. Waite's lime soap
ɾr as a damp proof course on a small pillar of pila bricks
h he had built in wet ground. It had proved very efficient,
·he had found it expensive.

Mr. Waite advocated a layer of concrete over the whole
ı of a building at floor level to avoid joints at the dividing
ls, but would not cracks subsequently develope in any case
ue to settlement and contraction ?

MR. HARFORD considered that the mortar used also
uired attention. If the bricks were well burnt, efflorescence
not affect them ; but if they were underburnt, they crumbled
7 during the first season. The damp seemed to get through
ıortar. He had excavated buildings which had been ruined
lorescence, but had never found any efflorescence below
ↄ level ; and from this, he concluded that it was the action
air that brought out efflorescence on damp walls or

R. NICHOLSON suggested that efflorescence in some
ht be due more to the surkhi in the mortar than to the
... There was a great difference of opinion regarding the best kind of brick to utilise in making surkhi. Some considered that underburnt bricks were necessary so that the surkhi should be able to enter into chemical combination with the lime, others deprecated the use of underburnt surkhi, and insisted on surkhi being made from practically fully burnt brick. He once had an unfortunate experience on a large work he was constructing, when two horizontal joints far removed from each other opened out. There was four feet of masonry above the joints, and on dismantling, it was found that the mortar had entirely disintegrated. The faulty masonry in both cases had been built the same day, and it was found that owing to a shortage of the regular surkhi supply, some very underburnt material had been used that day. An old Roorkee treatise had been found containing the remark that underburnt surkhi, made from earth with salts in it, was very liable to disintegrate mortar, and this was accepted as the cause of the mishap.

Efflorescent salts might be produced in the most carefully prepared bricks during burning by the use of inferior coal, which caused sulphur dioxide to be absorbed ahead of the fire by the condensation of the moisture on the bricks.

A waterproof course in an outer wall might fail if t contained efflorescent salts, since during rain the salts wot dissolved and might get splashed on to the wall abov waterproof course by the dripping from the roof or heavy ra

Whether it was the salts in the bricks, or the salts car. up from the ground by capillary attraction, that was the cause the trouble, could be settled by analysing a few bricks n ground level and some from the top of the building.

MR. MILLER BROWNLIE said he had been successful stopping efflorescence in buildings by what amounted to a dam proof course applied to the walls above ground level. Tl consisted of two coats of coal tar applied hot, each coat be dusted over with dry cement, and the second coat only app when the first was thoroughly dry. He had stopped effl scence in floors by applying the same damp proof course to surface of the lime concrete or other foundation immed under the wearing surface. The action appeared to be c the closing of the capillary tubes stopping the moisture risin the subsoil into the superstructure. The subsoil water districts where this treatment was successful contained percentage of saline matter. The treatment only cost to Re. 1-8 per hundred square feet per coat.

MR. HARFORD remarked that from the discussion it seemed to be an assumed fact on the part of the Congress that the engineer in charge of a work supervised his own brick making! What usually happened was that work was suddenly sanctioned, and the engineer had to get his bricks anywhere at all. The introduction of efflorescence into a building from below had so far only been discussed; it also, however, occasionally made its appearance from the top, and this was due to leakage. The great thing was to keep damp out, and there would be no trouble. He was satisfied that an efficient damp proof course with dry cinders underneath the floors and round a building would do away with all trouble from efflorescence.

RAI BAHADUR BISHAMBAR NATH said he had carried out several experiments for preventing the action of saltpetre at Muzaffargarh, which was one of the worst places in that respect in the Province, and found that the quality of the water and the degree of heat used in the manufacture of the bricks had a great deal to do with the matter. The Muzaffargarh water contained salts in solution, which during the cold weather crystallised and burst both bricks and plaster in the preparation of which it had been used. Under-burnt bricks, if exposed to the weather, were e susceptible to the action of saltpetre than well burnt or over-ıt bricks, but if used in the body of a wall, or under ground, ıained intact as was evidenced in the demolition of the old ısil building at Muzaffargarh. The under-burnt bricks were ug up whole from the foundations and stacked for auction, but a week later when he happened to pass that way he was surprised to find a continuous heap of surkhi in place of bricks. The latter had crumbled up under atmospheric action though they had remained unaffected for forty years while underground in the foundations.

In some lime pointing which he did on the gateway to the old treasury building, which was built of small country bricks with mortar joints as wide as the bricks themselves, he used canal nstead of well water, and *sakar* (very small kankar almost as fine s coarse sand,) collected from the neighbouring sand hills instead surkhi. This was his most successful experiment, but the inting only lasted a couple of years.

Small country bricks burnt in a *pazawah* were less liable to action of saltpetre than bricks burnt in a kiln, as they were er annealed by the more gradual raising and lowering of the erature. *Pazawah* bricks were burnt uniformly and are while kiln bricks have only their outer skin hardened and are brittle.

He had also had bricks coated with a solution of bichromate of potash, glue, and water in the proportion of one, two, and ten by weight, and after drying had deposited the bricks in a cemetery where all the brick work was subject to the ravages of saltpetre. After a couple of months of a very bad season he found that there had been no action on the bricks though these were under-burnt.

To prevent damp rising, he agreed with Mr. Brownlie in the efficacy of a course of coaltar, or better still of bricks dipped in molten asphalt, though in an experiment at Shalamar which he had carried out several years ago, he had dipped the bricks in a solution of asphalt, but on his return to Lahore after an absence of fifteen years he had found the walls as bad as ever, but in this case the damp proof course was only $4\frac{1}{2}''$ deep and did not extend through the whole thickness of the wall.

MR. GIBB suggested that the quantity of salts contained in the building material at the time of construction was not usually sufficient to cause serious damage. Salts initially in the building naturally came out on the surface in the first year or two and were washed off, and efflorescence did not ordinarily appear again. Serious damage only occurred in old buildings, a seemed evident that this damage was caused by the salts fe the wall from the soil at its foundation.

MR. STAINTON considered that what they had to a was any capillary action through the brick, and should fill up outer pores of bricks or plaster exposed to damp with so water proofing substance. A waterproof solution known a solignum asphalt had been tried on the outside walls of the Ci Surgeon's residence at Multan and from what he had been to (he had not actually seen the building since the experimen it had stood well through the last rains, and the building showe no effects from saltpetre. The idea in this instance, was to wate proof up to a height of six feet from the damp proof cour as saltpetre only ravaged from ground level up to five or six fe

MR. WAITE in reply said that the discussion was r concerned with different suggestions for keeping damp out of buildings than criticisms on his paper. The fact that cryst tion of certain salts would take place in any case, and th action would ultimately lead to the destruction of the brick or plaster, had been lost sight of, though such actic undoubtedly aggravated by damp. Mr. Wilsdon's int experiments did not help much towards a practical soluti problem. Experience proved that a machine pressed brick w much better than one that had been slop moulded, and consequently it was not easy to see how enlarging the pores would, in practice, help matters. He quite agreed, however, that the surest method of getting rid of efflorescence was to burn bricks at a sufficiently high temperature to ensure any alkalies present combining with the silica in the clay.

His rate for lime soap plaster, averaging rather more than half an inch thick, had worked out to about Rs. 9 a hundred square feet. Disintegrating also took place below ground, but to a less extent than where it was aggravated by atmospheric action.

MR. ORR in summing up an interesting discussion, said he was not satisfied that the last word had yet been said on the prevention of efflorescence, and hoped those interested would continue their investigations.

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