tials the grinding and the use of pure materials are incumbent on the parties furnishing the paint. The proper proportioning of the pigment and liquid, the use of dryer of the right kind and in the right amount, and the skill and care during the application, are incumbent on the foreman painter or his subordinates. It may be thought that in treating this subject of the proper application of the paint, the brush may be regarded as an essential element, and this undoubtedly does have an influence, especially in brush marks. However, our experience indicates that this element is less important than would generally be thought, as a skillful painter, even with a poor brush, will make a good job where an unskillful man with a good brush fails. We think it fair to say, however, that it is more wearisome to the arm, and more difficult to get good results with stiff brushes than with those which are more soft and pliable; also in our judgment there is very little economy in using poor brushes.

## MANUFACTURES AND MATERIALS

### WEATHERING OF BUILDING STONE.*

At the last annual Convention of the Ontario Association of Architects, Mr. Alan Macdougall, Chairman of the Toronto Branch of the Canadian Society of Civil Engineers, very kindly offered some remarks on the weathering of stones in buildings that had come under his notice.

Mr. Macdougall described also some ominous cracks that had occurred without any apparent reason in the tower of a church in St. John's, Newfoundland. The tower was built upon solid rock, and the only conclusion he could come to was that the corner of the tower had moved bodily, or in other words, slid upon the surface of the rock. Whatever movement had taken place was, however, arrested, and the building had been in the same condition it now was in for many years.

One result of Mr. Macdougall's investigations had been that he was certain *imported* stones did not stand a foreign climate as well as native stones. Stones found under certain conditions of atmosphere and climate were more capable of resisting disintegration under the same influences than stones found under different conditions. A building stone might be very excellent in its native country, but could not be trusted to withstand climatic influence of an entirely different nature to that of its own land.

Mr. Macdougall's remarks were very interesting, and led to a discussion, which we give below.

DISCUSSION.

The President: I am sure we are all very much indebted to Mr. Macdougall for his very interesting paper. It introduces a new feature in the discussion of building material from what we have been accustomed to.

Mr. Gambier-Bousfield: I rise to move a vote of thanks to Mr. Macdougall for his paper. I do so with special gratitude, because he is not a member of our Association, but he was kind enough to volunteer this paper because he knew it was a subject that would interest us all very much indeed; and it has been one which has given us cause for a good deal of thought, and I hope to hear from some of the members something more like the "Weathering of Stones." I should like to ask Mr. Macdougall if he has noticed the curious weathering of granite under frost and sun. There are two granite rock crosses standing in a small open space in England—I cannot just recollect the spot—and on the south side the sun has caused the granite to flake off to the depth of three quarters of an inch. The appearance is just like a tree trunk with pieces of bark pulled off. Those crosses have stood there probably for three or four hundred years.

Mr. Langton seconded the motion of thanks.

Mr. Billings: Did I understand that the crack went the whole way down in a straight line?

Mr. Macdougall: No, but almost a straight line.

Mr. Billings: It is possible there was a weakening in one stone first, and the other was cracked by pressure.

Mr. Macdougall: It must have been something of that kind. In that particular case there must have been some weakening somewhere to cause the first, because it would not be possible that you would have one cleavage generally running all through a number of stones; that is the curious part of it. Whether it is a weakness due to foundation I can't tell. The stone that forms the backing of the tower and the local stone has not given, and when you look at the wall of the cathedral you don't notice the cracking there, nor on the bishop's palace immediately adjoining.

Mr. Billings: Is it a stone that has some crystalline filling that is easily soluble by the humid air?

Mr. Macdougall: Of course it would be. Every stone has a certain cleavage plane, but you find what we technically call "dries" which comes out afterwards by the weather. The curious part of this was, there was such an immense deal of it.

Mr. Billings: There is a question I want to ask in connection with the efflorescence in Halifax, where they use so much of that brown stone. It was said to have been owing to the fact that the stone was taken from between high and low tide, and it was the salt that caused that very largely. I don't myself think it is so. I have the impression that the Halifax men have been content with the poorer qualities, and have shipped the best to Boston.

Mr. Macdougall: Is it a local stone?

Mr. Billings: That from Hopewell and Fairville. At Ottawa, in the balustrade of the steps of the Commons and Senate, the columns have gone the same way from efflorescence, and we thought it was from the sulphurous acid, because it was the Ohio sandstone that was used there. Now they are putting in bronze balustrades.

Mr. Macdougall: In the inside of the House of Commons?

Mr. Billings. No, the outside. They are putting in bronze balusters to support the Ohio sandstone rail, just owing to that cause. They have had several times to put in fresh Ohio sandstone because they never stood. I think our own Canadian sandstones and limestones are far superior to those from Ohio. We have in a great number of quarries in Canada very good stone, and still the people bring in stones from other countries, especially that Ohio sandstone, which behaves very badly in this climate.

Mr. Faull: Mr. Macdougall said the British Houses of Parliament were built of Portland stone. I think that is a mistake. I think it is Yorkshire stone, and that there is no portion of the Portland stone in them. Might not those cracks in the stone be caused by temperature? Where there is a large stone space in an intense cold, say 20° below zero, the interior of the stone would be of that temperature; then if a sudden change should take place, say 15°, in the course of a short time the outside would expand, and by that sudden expansion and contraction I think it would be very likely that the stone would crack. Now, in making large castings it would be necessary to make preparation that the temperature should alter after a long period to prevent fracture. These stones would be subject to fracture, I presume, much in the same way as castings would be.

Mr. Belcher: I recollect in England some thirty years since where a tower similarly situated cracked in a similar manner, and Sir Gilbert Scott was called in and he removed a portion of the under tower and discovered the cause to be a rounding in the rock, which was not levelled off perfectly level with the imposition of the building and it slid on the rock. In looking at your sketch there, it occurred to me that the front portion of the tower might have been on a level plane, and that the rock just curved off where the wall exists, and hence the fracture.

Mr. Macdougall: I don't think you can account for the long fracture in any other way than that there must be some slight defect in the foundation. It may be that the foundation was not laid perfectly level, or some stones not being perfectly level cracked, and that caused the other crack. With reference to the weathering of granite, no great observations have been made so far as I personally know or my study of the question goes. The granite of this country has not been sufficiently long put up to make any close calculation or examination into it. There is no doubt a granite, in its perfectly pure geological definition, could be put down as a composition of quartz and feldspar, and it is the feldspar which really gives the strength to the granite. If you have a feldspar which is of a soft nature, the action of the weather will attack that, and through that disintegration will take place. The matter was investigated partly by Prof. Geikie and also by Prof. Pfaff, but neither came to any conclusion on the subject. The matter mentioned by Mr. Belcher is very interesting; I was not aware of it. As to the life of building stones, I am not prepared to say anything, but I think the question is an extremely interesting one and I shall certainly make it a point of study next year, and if I can on any future occasion give you any information I shall be pleased to do it. (Applause). I think the effect on the stones in Ottawa is due altogether to their position; that is exactly the position of those tombstones I mentioned—they are in the angle of a wall; and this stone I showed you as bulging was exactly so—in the angle of the wall. There you have a very large amount of moisture, with the action of the frost, and no doubt the sulphurous acid and also carbonate of oxide; because you have noticed that in certain winds the smoke from the buildings is blown down, and you get a very strong smell off a great many buildings of what you would commonly call "coal gas," and when that is blown down directly on to the building its action must affect the stone. That is Ohio stone, is it not?

Mr. Billings: Yes, it is from Amherst, near Berea.

Mr. Macdougall: I suppose it is from the same stratification of rock?

Mr. Billings. Yes, it is all from the Devonian sandstone. The water falling, then, as you say, brings down the sulphurous acid, because in the fire-places they have bituminous coal all through the building, and a great broad stripe is visible down through the angle there.

Mr. Macdougall: That is just exactly the cause. The sulphur and carbon in it comes down and coats it.

Mr. Balfour: With such an example as has been given us on the board, with stone in the neighborhood of Kingston, I would account for it in altogether a different way. Taking that just as it stands before us, I would put this version on it. The weathering given us there between the two windows has on the start taken water—perhaps through the joint just on the coign. The water has gone through that stone and softened the mortar beneath it. The mortar has taken water from that crack, and the frost, expanding the mortar, has snapped the first stone. That would take place probably in some sudden change of weather. That would go on from month to month and year to year, and the water would follow that down until it came to the bottom. After going a certain distance below that belt again, the mortar being first softened, made sand of right under the belt, the stone next above it has a bearing on the inner corner and nothing on the outer. As soon as that goes down the weight is thrown on the corner, and that stone is snapped; and it will follow it up. We had an exact example of that in the Roman Catholic cathedral in Kingston. There is a tower there, and small ones on the corners, that cracked, and weathering was just exactly in that position; and I saw that thing going and followed it for ten or fifteen years, and I think there is no doubt that that is the way that went.

Mr. Dick: The instances of the weathering of stones that have been laid before us this morning, as well as the experience of most of us, go to show the great necessity of having a scientific investigation of all the building stones that we use, both native and imported. (Hear, hear). We have all seen instances of failure from using a weak stone where a strong one might have been had. I remember a case in my own experience on an arcade carrying considerable weight, granite columns and limestone caps. These caps crushed under the weight. I had the arches shored up, the caps cut out and replaced with red Credit Valley stone about the same size as the original cap. This stood the weight perfectly, and stands to this day without a sign of a crack or failure. Mr. Macdougall will recollect the parish churches of Edinburgh, which were built of Leith stone—a stone which was very soft when it came from the quarry, but in the course of a few years became so intensely hard that no stone-cutter liked to cut it. After sixty or seventy more years every course on those churches was as sharp as the day it left the quarry, while on other buildings made of local stone, they had become quite soft and ragged. I never could understand why the balusters at Ottawa should have gone the way they did unless the disintegration arose from the way they were placed on the top of the landing, where they were exposed to chemicals being brought down from the atmosphere or from the roof—more probably they washed down from the soot deposited on the roof. I do not see any other way of accounting for it, unless it may be that some chemical such as salt has been used at some time on the steps to melt the ice at certain times. Salt might be injurious. However, there is another circumstance that has been frequently observed in England and Scotland, and that is, that a stone always wears best in the district in which it is quarried. (Hear, hear). Many instances have been noticed of stone taken to London, where there is no building stone in the neighborhood—taken from the North of Scotland, for instance—which would not stand well in London, though it stood well in its native district. Of course that might be accounted for by the amount of sulphurous acid and other chemicals in the London atmosphere; but still it seems to be a matter of fact that a building stone does stand best in the district in which it is quarried. We are rather unfortunately situated in that respect in Toronto, in so far as we have nothing but intractable stone to work, and are therefore dependent on our neighbors; and the stone must be brought, too, a very considerable distance from its native district before we can use it; therefore it is not likely that it will stand as well as it would have done

* Abstract of paper read at the Third Annual Convention of the Ontario Association of Architects, by Mr. Alan Macdougall, C. E., and discussion thereon.