USE OF DOLOMITE FOR FINISHING COAT IN MASONRY

H. D. GUNAWARDHANA* AND P. P. S. P. DIAS

*Department of Chemistry, University of Colombo, Colombo 3.**(Date of receipt : 18 October 1985)**(Date of acceptance : 10 February 1987)*

Abstract: The major drawback in the application of dolomite as a substitute for limestone is the appearance of cracks when calcined and subsequently slaked dolomitic quicklime is applied on the plaster in the form of a finishing coat. Investigations into the cause for the appearance of cracks have revealed that there are five major factors which influence the appearance of cracks. Out of the factors identified, more extensive studies were carried out on factors such as moisture content of the plaster and percentage of carbon dioxide of dolomitic quicklime. The optimum conditions for the application of dolomitic finishing coat without the appearance of cracks have been recommended. The appearance of cracks can be mitigated by achieving complete slaking of magnesium oxide component before the slaked calcium oxide is set. Pilot scale application of a dolomite under recommended conditions revealed promising results.

1. Introduction

Dolomite³ is a carbonate of calcium and magnesium with 1 to 3% impurities such as quartz, gypsum, etc. The content and the colour of the impurities determine the colour of the rock. Dolomite or dolomitic limestone has 40 to 43% magnesium carbonate. Magnesium carbonate dissociates at 402 to 480°C, whereas the magnesium carbonate component of dolomite decomposes at higher temperatures i.e. 590°C. As a result the magnesium oxide is hard-burned in varying degrees before the calcium oxide is formed, which requires a temperature of about 898°C. It has been shown³ that the degree of hard-burning can be mitigated by cooling the quicklime immediately after the CaCO_3 is calcined, and also by calcining at minimum and constant temperature for a longer duration. The traditional dolomitic limestone kilns in the Matale district of Sri Lanka seem to follow a procedure to minimize hard-burning.

Slaking of dolomitic quicklime can be represented by the following equation:⁵

*Centre for Analytical Research and Development.

The calcium oxide component of dolomitic quicklime is slaked **first**. The hard-burned magnesium oxide component of dolomitic quicklime requires pressure for complete hydration.

When the dolomitic quicklime is slaked in the normal way and applied on the plaster, the appearance of cracks or fractures becomes inevitable. The appearance of cracks in cement is due to the expansion caused by the conversion of magnesium oxide to magnesium hydroxide after the setting of the hydrated components of cement.⁶ Therefore, it is necessary to use limestone free of magnesium in the cement industry. When the dolomitic hydrate is applied on the plaster the hydrated calcium oxide component undergoes setting.² This could be attributed to the gel formation and the subsequent hardening. The slaking of magnesium oxide is slow and water penetrates into the surface pores. This exerts great internal expansive force and causes it to fracture. This paper describes an investigation on the factors which influence the appearance of cracks on dolomitic finishing coat.

2. Experimental Procedure

Analytical-grade chemicals were used wherever possible.

2.1 External rendering:

Mortar mix of 1:1:5 (cement: dolomitic hydrates: sand)⁵ was used for external rendering on the brick work. The moisture content of the resulting plastered finish was determined by one of the following methods.

- (i) Karl Fischer Method:⁶ Karl Fischer reagent was prepared using methyl cellosolve as the solvent. Both visual and electrometric end-point detection methods were carried out.
- (ii) Drying and weighing method:⁷ A sample of the plaster was dried at 110°C for three hours. The difference in weight before and after drying was used to calculate the moisture content.

2.2 Determination of carbon dioxide content:¹

Syrupy phosphoric acid was added to a weighed sample and heated gently, evolved gas was passed through a solution of syrupy phosphoric acid followed by a U-tube packed with phosphorus pentoxide and pumice stones impregnated with copper sulphate. The gas was then passed through two

U-tubes, each containing soda asbestos (carbosorb) and phosphorus pentoxide. Increase in weight of the two U-tubes containing carbosorb gives the carbon dioxide content of the sample.

2.3 Application of dolomitic finishing coat:

Dolomitic quicklime of the particle size of 60 to 100 mesh was slaked for 23 hr., the excess water was filtered off and the resulting putty was applied on the plaster maintaining the thickness of about 3.5 mm. The traditional method employed in the Matale district of Sri Lanka, involves the calcination of pieces of dolomite (about 2 cm diameter) in a kiln for about 48 hr. and slaking them in a basin with excess of water. Disintegration of the pieces occurs during this process, leading to a separation of heavier silica particles from the slaked dolomite particles. The traditional method was adapted in the laboratory by heating pieces of dolomite at about 900°C for about 90 min., in a muffle furnace and then slaking them in a beaker of water. After 23 hr. the slaked dolomitic quicklime was removed without agitating the bottom of the beaker, filtered and applied on the plaster.

2.4 Analysis of dolomite:

1.000g of sample was dissolved in perchloric acid (10 cm^3), heated to dryness on a hot plate, cooled, added a mixture of 10 cm^3 of perchloric acid and 10 cm^3 of water and filtered through a Whatman No. 40 filter paper into a 250 cm^3 volumetric flask. The filter paper was ignited quantitatively to determine the acid insoluble substances. The filtrate was made up to 250 cm^3 and used in the determination of calcium, magnesium and iron by EDTA titration.⁸

3. Results and Discussion

3.1 Possible cause for the appearance of cracks:

It has been reported⁵ that magnesium oxide component of dolomitic quicklime requires pressure for complete hydration. Therefore, a sample of dolomitic quicklime (carbon dioxide content 6.03%) was slaked for 45 min. in an autoclave under a pressure of 15 lbs per sq. inch at a temperature of 121°C . When this sample was applied on a plaster having a moisture content about 2%, no cracks appeared on the resulting finishing coat. The undesirable expansive forces which are responsible for the appearance of fractures will not be created, if the magnesium oxide component is completely hydrated (slaked). However, the pressure slaking of dolomitic quicklime is not feasible in the cottage level building construction.

This necessitates the need to investigate the influence of various factors responsible for the appearance of fractures during the normal use of dolomitic quicklime for finishing coats. Our investigations revealed that application of slaked dolomitic quicklime under certain conditions gives a perfect finishing coat with no fractures. It was possible to identify that the following factors influence greatly on the appearance of fractures.

- (a) The moisture content of the plaster at the time of the application of finishing coat.
- (b) The carbon dioxide content of dolomitic quicklime.
- (c) The particle size of dolomitic quicklime.
- (d) The slaking time of dolomitic quicklime.
- (e) The composition of dolomite.

It is apparent that the adjustment of these factors during the application should give a perfect finishing coat.

3.2 Effect of moisture content of the plaster at the time of the application of finishing coat

Dolomite of composition ($\text{CaO} = 30.5\%$, $\text{MgO} = 21.3\%$ and $\text{Fe}_2\text{O}_3 = 0.45\%$) was calcined, slaked and applied on the plaster having a moisture content of 16.8%. This application of the finishing coat and the determination of the moisture content of the plaster were continued daily. It was observed that perfect finishing coats can be obtained if the moisture content of the plaster remains at 10% or above. Cracks were observed during the application of the same dolomite under similar conditions, but keeping the moisture content of the plaster below 10%.

The continuous supply of water from a plaster possessing an adequate moisture content will prevent the early setting of the hydrated calcium oxide component of the dolomitic quicklime. This in turn gives sufficient time for the complete slaking of the magnesium oxide component. However, the tendency for the calcium oxide component to undergo an early setting, exerts a pressure on magnesium oxide. Under these conditions, with an adequate supply of water from the plaster magnesium oxide component undergoes slaking rather rapidly. This enables uniform setting of both components. Undesirable expansive forces will not be created under these circumstances.

3.3 Effect of carbon dioxide content of dolomitic quicklime on the appearance of cracks

It has been observed that 'hard-burned' dolomitic quicklime shows the appearance of cracks irrespective of the moisture content of the plaster.

The extent of 'hard-burning' can be measured in terms of the carbon dioxide content of the dolomitic quicklime.

Table 1 shows the appearance of cracks when the finishing coat is made out of dolomitic quicklime having the carbon dioxide content less than 1.0% (i.e. hard-burned). Therefore, it is essential to control the carbon dioxide content of dolomitic quicklime which is entirely dependent on the calcining temperature and duration. The calcining process expels carbon dioxide from magnesium carbonate more readily than calcium carbonate.³ Since the proportion of magnesium carbonate to calcium carbonate differs usually from deposit to deposit, either the calcining temperature, duration or both should be varied accordingly. It is clear from Table 1, that high carbon dioxide content of dolomitic quicklime (soft-burned) is more desirable. But the finishing coat made up of soft-burned dolomitic quicklime having a carbon dioxide content greater than 10% was found to possess an undesirable texture. The finishing coat was soft and easily removable. Experiments were conducted to obtain the desirable carbon dioxide content by varying the heating time. The results are shown in Table 2. The results obtained by the application of samples of dolomite given in Table 2, as finishing coats are indicated in Table 3.

Table 1. Effect of Carbon dioxide content on the appearance of cracks.

Time taken to obtain appro- priate moisture content (in Hours)	Moisture content of the plaster (%)	CO ₂ Content			
		1.4%	0.9%	0.6%	0.4%
23	14.18	N	N	N	C
47	8.79	N	C	C	C
167	1.46	N	C	C	C
191	1.37	N	C	C	C
215	1.18	N	C	C	C
239	1.10	N	C	C	C
359	0.83	N	C	C	C
575	0.81	N	C	C	C

N = No cracks

C = Cracks

Table 2. Effect of heating time at 900°C on the carbon dioxide content of dolomitic quicklime.

Heating time (min)	35	70	95	210
% CO ₂	12.66	6.35	2.57	2.46

Composition of Dolomite:

CaO = 31.84%, MgO = 20.30%, Fe₂O₃ = 0.56%.

Table 3. Influence of carbon dioxide content on the appearance of cracks.

Moisture content of the plaster (%)	Carbon dioxide content			
	12.66%	6.35%	2.57%	2.40%
13.94	N	N	M	M
12.61	N	N	M	M
10.19	N	N	M	M
7.52	N	N	M	M

Composition of dolomite as in Table 2.

N = No cracks, C = Cracks, M = Mosaic grooves.

Even though any fractures did not appear on the finishing coat made up of dolomitic quicklime having the carbon dioxide content 12.66%, the texture of the finishing coat was found to be soft and unsuitable. However, the finishing coat made up of dolomitic quicklime having the carbon dioxide content 6.35% (Table 3) was found to fulfil the necessary requirements. Therefore, the carbon dioxide content of dolomitic quicklime should be maintained in the range 5 – 10% in order to achieve the requirements for a finishing coat.

Boynton³ has reported that, at a calcining temperature of about 900°C, the magnesium oxide component undergoes hard-burning in varying degrees. The degree of hard-burning therefore should be proportional to the duration of heating. High degree of hard-burning reduces the rate of hydration of magnesium oxide resulting in an increased tendency for the appearance of cracks when applied as a finishing coat.

3.4 Effect of particle size of dolomite on the appearance of cracks

The relationship between the particle size of dolomitic quicklime and the moisture content of the plaster was observed while keeping the other factors such as carbon dioxide content, etc., constant. Nevertheless, there was a practical difficulty of obtaining an equivalent value for the carbon dioxide content of dolomitic quicklime of varying particle sizes. The carbon dioxide percentages of 300 mesh, 150 mesh, 60 mesh and 30 mesh particles of dolomitic quicklime appearing in Table 4 were 6.26%, 15.8%, 4.5% and 9.7% respectively. It is evident from the Table 4, that the smaller the particle size of dolomitic quicklime the greater is the resistance acquired by the finishing coat against the appearance of cracks. If the particles are very small, undoubtedly there is a complete hydration of both calcium oxide and magnesium oxide components during the normal slaking, thus enabling the uniform setting of both components after the application. Therefore, there is no tendency for the appearance of fractures. Table 4 shows that 300 mesh particle size is the most appropriate, however, there is a practical difficulty in obtaining such small particles especially in the cottage level. Therefore, our studies were restricted to 60 – 100 mesh particle size which could be obtained without the employment of sophisticated machinery.

Table 4. Influence of particle size of dolomitic quicklime on the appearance of cracks

Moisture content of the plaster (%)	Particle Size			
	300 mesh	150 mesh	60 mesh	30 mesh
16.8	N	N	N	N
15.4	N	N	N	N
13.5	N	N	N	N
11.2	N	N	N	N
6.1	N	N	C	C
5.5	N	N	C	C
4.8	N	N	C	C
3.8	N	N	C	C
3.6	N	N	C	C
3.4	N	N	C	C
2.9	N	N	C	C

N = No Cracks

C = Cracks

3.5 Effect of slaking time of dolomitic quicklime on the appearance of cracks

Application of dolomitic quicklime possessing a carbon dioxide content 2.47%, on a plaster of moisture content 4.33% after slaking for 18, 24, 42, 96, 138 and 216 hours showed cracks irrespective of slaking time. Cracks have not been observed at any moisture content higher than 4.33%. From these results, it is evident that complete hydration of magnesium oxide component will not occur under normal conditions. The extent of hydration of magnesium oxide component is therefore independent of the time period in which dolomitic quicklime is kept in contact with water. The exposure of slaked dolomitic quicklime to atmosphere over a long period results in a recarbonation by atmospheric carbon dioxide. As a result, the standard slaking time of 23 hours was employed throughout our investigations.

3.5.1 Effect of the composition of dolomite on the appearance of cracks

Four samples of composition as shown in the Table 5 were crushed and calcined at 900°C for 90 minutes. The results of the application of these dolomitic and high calcium limestone samples are shown in Table 6.

Table 5. Composition of dolomite and high calcium limestone used.

Sample Number	% CaO	% MgO	% Fe ₂ O ₃	% Acid Insoluble matter
1	53.65	1.14	0.36	0.62
2	30.80	21.69	0.36	0.40
3	31.09	21.59	0.15	1.89
4	54.82	1.04	0.34	4.38

Table 6. Effect of using different dolomitic and high calcium limestone on the appearance of cracks

Sample Nos. 1, 2, 3 and 4 are as in Table 5.

Moisture content of the plaster (%)	Powdered Samples				Traditionally Slaked Granules			
	1	2	3	4	1	2	3	4
11.59	N	N	N	N	N	N	N	N
11.48	N	N	N	N	N	N	N	N
11.23	N	N	N	C	N	N	N	N
10.02	M	N	N	C	N	N	N	M
4.25	C	C	C	C	C	C	C	C

N = No Cracks, C = Cracks, M = Mosaic grooves.

A method similar to the traditional way was adapted in the laboratory by crushing dolomite into granules of about 1.5 cm diameter and calcining under the same conditions. The slaking of these dolomitic quicklime granules gave a powder which was applied on the plaster in a similar manner. The results are also shown in Table 6.

It is apparent from Table 6, that the appearance of cracks is independent of the composition of dolomite. However, the early appearance of cracks in high calcium limestone (sample No. 4) could be attributed to the presence of a high percentage of acid insoluble matter such as silica. Independent employment of traditional slaking methods gave identical results. It is evident from Table 6, that superior results could be achieved by the employment of the traditional method. This could be attributed to the fact that a certain amount of acid insoluble matter is removed during the traditional slaking process as a result of the settlement of the acid insoluble matter at the bottom of the vessel used for slaking.

4. Conclusion

Out of the factors which govern the appearance of cracks on dolomitic finishing coats, the moisture content of the plaster at the time of the application of finishing coat and the carbon dioxide percentage of dolomitic quicklime are considered to be two major important factors. In conclusion, it is apparent that one can obtain a perfect finishing coat without any fractures if one applies slaked dolomitic quicklime of carbon dioxide content in the range 5 — 10%. Therefore, dolomitic finishing coat can be successfully applied without the appearance of cracks under the above conditions irrespective of the composition of dolomite. Moreover, under the use of any other conditions which provide adequate measures to prevent the differential hydration and setting of magnesium oxide and calcium oxide components of slaked dolomitic quicklime, it is possible to obtain dolomitic finishing coats without any fractures.

Acknowledgements

The authors are grateful to the Industrial Development Board of Sri Lanka for providing a research studentship to one of us (PPSPD). They also gratefully acknowledge the Natural Resources, Energy & Science Authority of Sri Lanka for providing a research grant and a studentship (PPSPD) to complete the project.

References

1. ALEXEYEV, V. (1969) *Humidity and Moisture*, Vol. 3 and 4, Reinhold, New York.
2. BIRCHALL, J. D. & HOWARD, A. J. (1978) *New Sci.* 78: 228.
3. BOYNTON, ROBERT, S. (1966) *Chemistry and Technology of lime and limestone*, Interscience, New York.
4. MICHELL JUR. J. & SMITH, D. (1948) *Aquametry*, Interscience, New York.
5. STOWELL, E. P. (1963) *Limestone as raw material in industry*, Imperial Chemical Industries Ltd., Oxford University Press.
6. TAYLOR, H. F. W. (1964) *Chemistry of Cements*, Academic Press, London.
7. WEXLER, ARNOLD, (1965) *Humidity and Moisture*, Vol. 3 and 4, Reinhold, New York.
8. WELCHER, FRANK, J. (1957) *The analytical uses of ethylenediaminetetra acetic acid*, Van Nostrand, Princeton.
9. THE LIMESTONE FEDERATION, (1959) *The Use of Lime in Building*, The British Lime Manufacturers, London.