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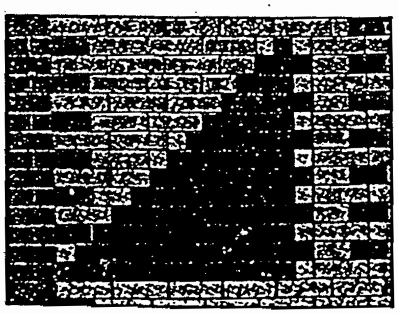
LIME MORTARS AND PLASTERS IN BUILDING

by K H Renton and H N Lee, Mortar Producers Association Ltd

The need to improve the standard of brickwork and blockwork structures and efficiency of various types of mortar formulations are of considerable interest — even controversy — in the building industry. Current market trends in the use of lime-based mortars and plasters in Europe, recent research work and comments on existing methods of testing mortars, are all mentioned in this article.



The contrasting use of mortar with different coloured bricks can be aesthetically pleasing

Mortar producers define 'pre-mixed' mortars as dry materials, which have been blended in a factory, and require only to be mixed with water on site before they can be used.

'Ready-mixed' mortars are mixtures of lime and sand, which require the addition of cement and possibly some water on site.

'Ready-to-use' mortars are factory-made materials which arrive on site ready to use, without any further preparation. Their use, however, does require considerable organisation of delivery and site handling by the producer.

DEVELOPMENTS

At the end of the Second World War, nearly all bricklaying mortar was mixed on site using combinations of lime, sand and cement, but both pre-mixed and ready-mixed mortars soon became available. For reasons of cost and convenience, ready-mixed mortar made greater progress, particularly in the UK and Germany. This was largely due to the marketing expertise employed by lime and mortar producers.

In other areas, notably Northern France and Belgium, where this expertise was not employed, there was a decline in the use of lime to the advantage of plasticised cement mortars.

In West Germany and the UK, ready-to-use mortars are now available and the technology is on offer by licence in other European countries. The German product has arisen from the surplus production capacity of the ready-mixed concrete industry and offers a plasticised cement-sand mortar, delivered in truck mixers. In the UK a cement-lime-sand-mortar is on offer in purpose-made vehicles.

There has been a significant increase in the use of coloured mortar, created by adding powdered pigments, and this material is now becoming popular on the Continent.

COLOURED MORTAR

Increasing quantities of ready-to-use mortar are expected to be supplied and a considerable percentage of this material will be coloured. Whether this material will be plasticised cement-sand mortar or cement-lime-sand mortar will depend on the marketing effort applied by the respective producers.

The use of lime in plastering has severely declined since the Second World War. Initially, gypsum plasterboard was the main competitor, and sales continue to rise. Other types of drylining proved more costly or less effective, and plasterboard is now a large and established system. A little later a pre-mixed gypsum-perlite plaster was marketed, and took a further large share of the traditional market.

This has been followed by a pre-mixed cement-lime-perlite plaster, which enjoys considerable support, although it is only produced at about 8% of the quantity of the gypsum product.

Both these pre-mixed plasters can be used for mechanical spray application and energy conservation regulations will encourage their use in increasing quantities in the future.

RESEARCH NEEDED

Continued growth in pre-mixed plasters, supplied in paper sacks and bulk containers is expected and if cement-lime-perlite pre-mixed plaster is available, it will command a considerable portion of the market because it is more universally suitable.

As competition from cement and gypsum producers developed, arguments in favour of lime in mortar needed to be supported by scientific research. The

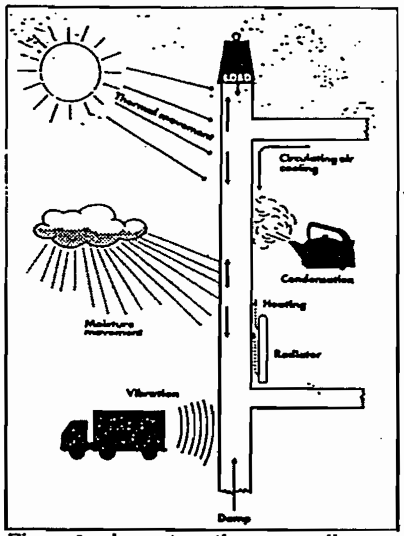


Figure 1: elements acting on a wall

Mortar Producers Association was formed in 1971 to this objective. Work is sponsored in members' laboratories and other suitable locations. Most UK producers of lime-based mortars are involved, with other interested groups as associates.

MATCHED MORTAR

A wall is required to support the roof and floors of a building and maintain acceptable conditions inside. There are a number of elements continually acting on the wall, namely the load, thermal and settlement movements, rain causing moisture movement, and traffic vibrations (see Figure 1). Similar movements occur inside, which are frequently opposite to the external force.

It is essential that walls have dry heads and feet and that the mortar is matched to the brick. Unnecessarily strong and rigid mortars can cause cracking of brickwork and lead to water penetration and frost damage.

The principal benefits of lime in mortars are workability, water retention, bond to units (ie, bricks or blocks), elasticity and durability.

Whereas workability can be provided by the inclusion of air in non-lime mortars, it cannot equal the regular performance of lime. Indeed, over-aeration can cause detrimental results leading to reduced bond and unsatisfactory masonry.

MORE INSULATION

A current programme has demonstrated that the addition of latex compounds, to cement-lime-sand mortar in the lower course of brickwork, will give more satisfactory insulation to ground moisture than present practice. The same improved mortar will also protect copings from rain penetration and is particularly effective in free-standing walls.

There is a great deal of published work on rain penetration, but little which compares lime mortars with non-lime mortars.

With this in mind, a research programme for the MPA was carried out by Ken Thomas, to compare three types of mortar. He showed that, given good workmanship, Fletton-type clay brick walls constructed with lime or non-lime mortars were equally resistant to rain penetration, when the bricks were laid frogs up. However, when the bricks were laid frogs down, lime mortars performed best. This is considered to be due to the high plasticity of lime mortars, enabling better filling of the frogs.

Penetration was predominantly through the clay bricks in the early part of these tests. With calcium silicate bricks the lime mortar performed better than non-lime mortars and in this series early penetration was through the perpendicular joints.

Another researcher tested 48 walls and concluded that walls constructed of lime-based mortars enable small cracks to be sealed by autogenous healing, ie, by depositing lime in a manner similar to that

Type of brick	Brick properties: Strength (mn/m²)	Brick properties: Suction rate (Kg/m² min)	Mortar designation	Type of mortar: Mix by volume	Type of mortar: Composition	Strength at 28 days: Mortar (N/mm²)	Strength at 28 days: Wall (MN/m²)
Engineering	46.04	0.93	i	1:¼:3	c:l:s	12.00	14.37
				1:3	c:s	16.18	14.84
			iii	1:1:6	c:l:s	4.40	9.30
				1:4½	mc:s	4.45	8.79
Fletton	40.00	1.25	iii	1:1:6	c:l:s	4.36	8.86
				1.4½	mc:s	4.29	7.85
				1:5	c:s + a	4.31	8.58
			iv	1:2:9	c:l:s	2.02	6.20
Calcium silicate	40.41	1.01	iii	1:1:6	c:l:s	4.34	12.68
				1:4½	mc:s	4.55	11.72
				1:5	c:s + a	3.46	10.55
			iv	1:2:9	c:l:s	2.28	9.51

Key:
c = ordinary Portland cement
l = hydrated lime (added as lime putty)
s = sand
mc = masonry cement
a = air entraining agent

Figure 2: effect of mortars on wall strengths

Type of mortar	Traditional	Middleweight	Lightweight
Consistence by dropping ball (mm)	10.1	10.2	10.0
Density of mix (kg/m³)	2020	1480	990
Water (% on wet wt)	17.7	15.5	51.0
Water retentivity (%)	95	92	94
Consistence retentivity (%)	60	50	60
Flow (%)	100	80	100
Air content (%)	4.6	23.0	42
Compressive strength cured under limewater (N/mm²)			
at 7 days	3.58	1.85	3.00
at 28 days	5.28	2.75	4.50
Flexural strength cured under limewater (N/mm²)			
at 7 days	1.32	0.72	1.48
at 28 days	1.92	1.20	1.98
Air dried bulk density (kg/m³)	1850	1375	800
Oven dried bulk density (kg/m³)	1750	1300	700

Figure 3: typical properties of various 1:1:6 plasters

in which a bond between mortars and unit is formed.

IMPROVEMENTS

Coupled with his work on rain penetration, Mr Thomas studied the effects of wetting a wall built with calcium silicate bricks and a 1:1:6 cement:lime:sand mortar, storing it for three months and retesting. Considerable improvement in the prevention of water penetration was observed.

The strength of a wall must be sufficient to support the total load applied to it, but laboratory tests on bricks and cubes of mortar do not necessarily give a true indication of the load-bearing capacity of the wall built with them.

To demonstrate this the MPA has tested walls built with three types of brick, using cement:lime:sand, masonry cement: sand, and cement:sand with air entrainment (see Figure 2).

A number of interesting facts arise from this work. When tested as laboratory samples, 1:¼:3 and 1:3 mortars showed that the presence of lime reduces the mortar strength by 25% when tested as a cube, but the final wall strengths are identical.

Generally, the lime mortar walls are slightly stronger than the cement mortar wall but there is marked improvement when they are built of calcium silicate bricks. With calcium silicate walls a 1:2:9 mortar is only one megaNewton per square metre weaker than a 1:5 cement:sand with entrained air.

These tests were carried out after the cement in the mortars had developed most of its strength; but it is known that over a long period a continuing carbonation of the lime in mortar takes place, which undoubtedly adds further strength to the brickwork.

Straight cement:sand mortars will gain about 75% of their ultimate strength in ten to 24 days. With cement:lime:sand mortars, the time required for ultimate strength development is much longer. Therefore, any small initial movement can be absorbed without breaking the bond between mortar and unit.

Even when cement:lime:sand mortars have set, there is sufficient flexibility to accommodate thermal and moisture movements without cracking.

PIGMENTS ENHANCE

The appearance of mortar has become an important factor in the designer's specification due to the introduction of coloured mortars. Pigments used are inert inorganic oxides and have no adverse effects on the properties of the mortars. They enhance the appearance of the brickwork and are permanent in effect.

While dry-lining with plasterboard has many good properties, the finish does not compare with that obtained with traditional plasters.

The introduction of pre-mixed lightweight plasters using perlite, and for some purposes vermiculite as an aggregate, opened up new areas of development for the trade. To complete the density range, a ready-mixed cement:lime:perlite:sand mortar was produced in the UK. The benefits of these plasters are in ease of handling and in enhanced insulation values.

Figure 3 gives comparative results for ready-mixed plasters tested in accordance with BS methods.

RENOVATION PROBLEMS

With the increase in renovation of old properties in Europe a problem arose when damp conditions caused the breakdown of gypsum plasters.

Normal cement-based plasters remained damp, causing decoration problems; and work was undertaken to develop a plaster which would set under damp conditions, dry out reasonably quickly, and prevent water remaining in the wall from reaching the surface.

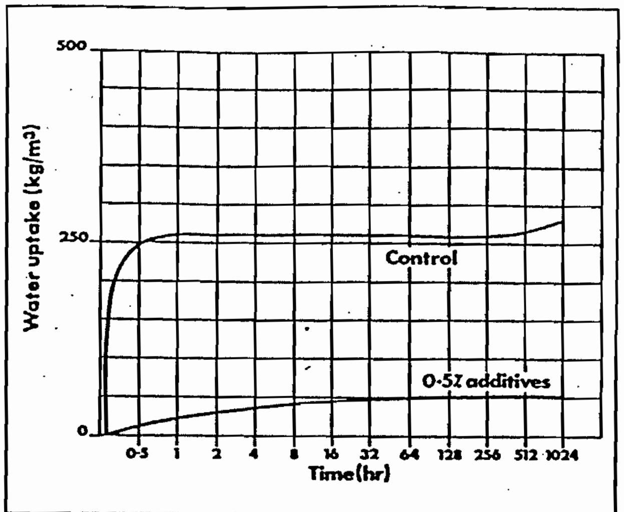


Figure 4: effect of additives on water uptake of 1:1:6

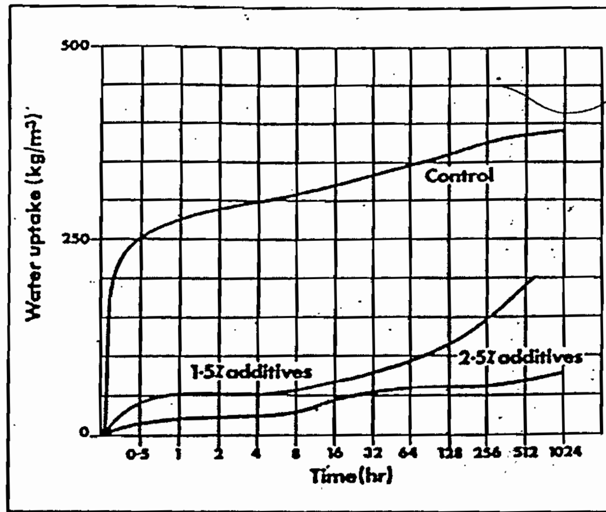


Figure 5: effect of additives on water uptake of lightweight plaster

Traditional and lightweight plasters were examined with 21 different water-resistant chemicals. To eliminate the difference in bulk density of the plasters the water uptake is expressed as weight per unit volume. Figures 4 and 5 show typical results using a 1:1:6 cement:lime:sand mortar and a cement:lime:perlite pre-mixed plaster.

CONCLUSIONS

The conclusion is that mortars should be factory produced to meet present-day requirements. Where ready-mixed mortars or ready-to-use mortars are available, they are preferable to pre-mixed mortars, partly on cost but more specifically by the use of lime in a plastic putty form.

Modern systems are available for providing lime putty quickly and satisfactorily from both fine quicklime or powdered hydrate, and it is our experience that the beneficial characteristics of lime are best exploited by the production of a lime putty before mixing. When pre-mixed mortars are necessary, dry hydrated lime is required and this will still provide considerable benefits when compared with non-lime mixes.

The inclusion of lime in mortars is beneficial, according to all indications. However, the results of testing and experience are still being emphasised to designers and contractors, as other forms of mortar can seem attractive under the influence of marketing pressure.

The research programmes described above were designed to provide convincing evidence for users about the benefits of lime. More work is needed to establish standard test methods in two particular respects.

Firstly, the results obtained by crushing a cube of mortar will only indicate the probable composition and this can be an unreliable guide to performance.

The Australian Standard 1960-74 includes the testing of brick prisms for compressive strength, which highlights the contribution of lime, particularly in association with calcium silicate bricks. This test is reportedly being considered for inclusion in American and Canadian standards, and it is hoped that the BSI will follow the Australian example.

Test series

The MPA is at present engaged in an inter-laboratory series of tests using this method. The results from one of these experiments are given in Figure 6. These show that the ratios of wall strengths to mortar strengths are 7:1 for a 1:3:12; 3:1 for a 1:2:9; 1.75:1 for a 1:1:6; 1:1 for a 1:½:4½; and 0:5:1 for a 1:¼:3.

In these tests the mortar strengths were determined in accordance with the requirements of BS 4551 at 28 days, using 25 x 25 x 100 mm prisms, and the four-brick-high piers were bonded with 10 mm joints and also tested at 28 days. The bricks were a Fletton-type clay brick with a compressive strength of 32.3N/mm². These tests show the value of matching mortar to units if load-bearing properties are required.

Secondly, there is the high cost of constructing test walls of which large numbers are required to reduce the coefficient of variation in any programme. Here, it would be of great value to establish the relationship between the test performance of samples reduced in size to the full scale.

Samples of various sizes from many of the test walls used in our experiments are being constructed. This is a protracted exercise, and a system of collating experience from other workers, which would allow an acceptable formula to be established, would be welcomed. This would permit a much greater volume of research work to be completed in any given period. It would reduce some of the variables, which admittedly will continue to occur in commercial construction, but it would also give more accurate information on the performance of brick masonry in certain important aspects.

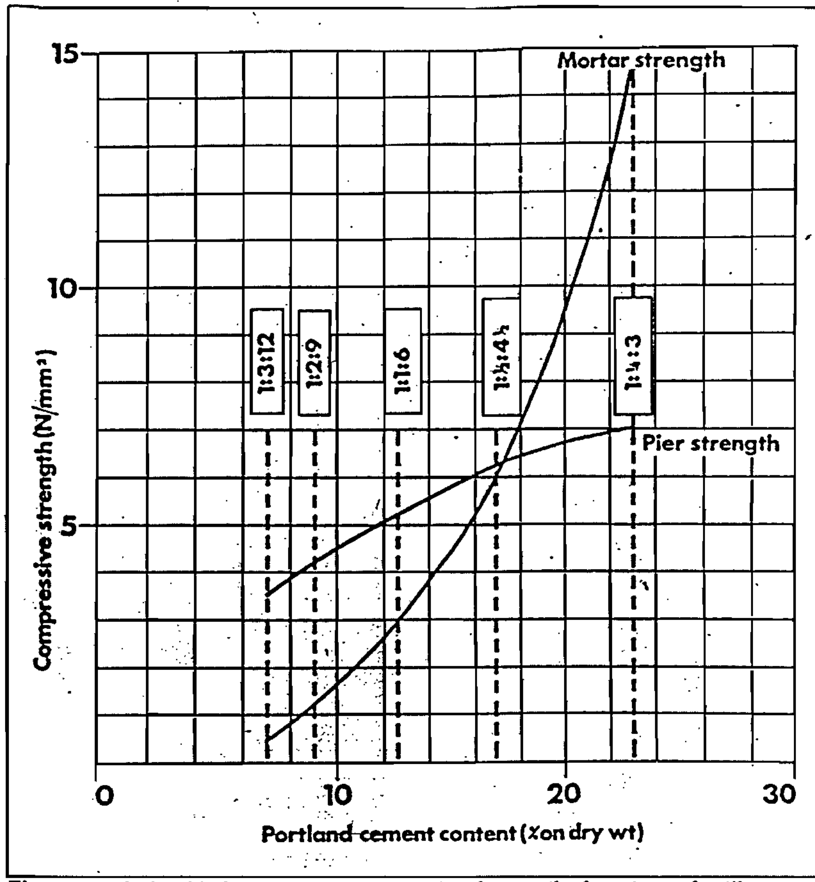
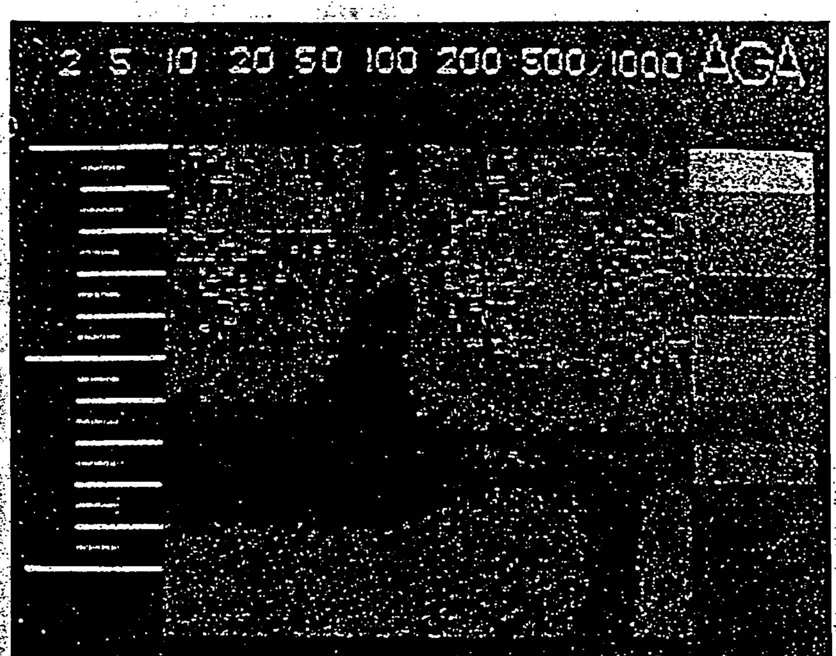


Figure 6: relationship between cement content and strength of mortar and wallette

26% heat loss detected through traditional mortar joints

Independent tests have shown that traditional mortar joints increase heat loss through low-conductivity blockwork by a staggering 26%. They also demonstrate that insulating mortar can cut this figure to only 8%. Carried out at Fulmer Yarsley's Thermal Laboratories, Redhill, the investigations prove that mortar joints must be considered when calculating the thermal properties of a structure. The insulating properties of jointing materials will be a prime factor in meeting the new draft building regulations on thermal performance. These set a U-value (thermal transmittance) target for walls of 0.45 W/(m²K) which, together with other measures, should reduce domestic heating requirements by about 20%. To achieve this with two-leaf brick and blockwork structures with clear cavities means relying heavily on low-energy autoclaved aerated concrete (AAC) blocks – either with a different jointing medium or larger blocks.



Thermogram of 125mm-thick block wall built from autoclaved aerated concrete with 10mm mortar joints. The heat loss (26%) through the mortar is indicated by the darkest areas in the photograph