Introduction

• Lime used in the past as a constituent of masonry mortar; today cement has largely replaced it for this purpose.

• It is still used in the making of the finish or putty coat for interior plaster.

• Lime is obtained from LIMESTONE. Pure limestone is \( \text{CaCO}_3 \) (calcium carbonate). Impurities like MgCO3, Al2O3, SiO2, etc may be present.

• Limes classified as non-hydraulic or hydraulic. Non-hydraulic limes do not harden without air being present (e.g. under sea).
2.1 Production of Lime

- Excavation of limestone
- Crushing
- Grading
- Calcination to obtain *quicklime*
- Pulverize (99% smaller than 0.15 mm)
- Mix with water under pressure
- Dry and pulverize to obtain hydrated lime
- Marketing
2.2 Practice of Calcination

- intermittent kiln (for small scale production)
- continuous kiln
- rotary kiln
- reactor kiln

KILN=FURNACE
2.3 Classification of Quicklimes (see Table 1.1)

According to Particle Size:

- lump lime (10-30 cm lumps)
- pebble lime (2-5 cm)
- granular lime (0.5 cm)
- crushed lime (crushed to a specified grading)
- ground lime (passes 2 mm sieve or less than 2 mm)
- pulverized lime (less than 0.15 mm or passes 0.15 mm sieve)
According to Chemical Composition:  
(see Table 2.2)

- High - calcium lime : (CaO ≥ 90%) rich, fat, caustic lime
- Calcium lime : 75 < CaO < 90%
- Magnesium lime : MgO ≥ 20%
- High magnesian (dolomitic) lime: MgO > 25%

According to Use:

- Mortar lime (used for stonework)
- Plaster lime
High Calcium Lime (fat lime):

- Produced by burning pure limestone, essentially calcium carbonate (CaCO₃) so as to drive off the carbon dioxide (CO₂) leaving calcium oxide or quicklime.

- When water is added to quicklime considerable heat is evolved, there is considerable expansion. Resulting product is calcium hydroxide (Ca(OH)₂).

- Although they are unlikely to be present in hydrated lime, unslaked particles tend to slake and expand after lime has been used; causing localized popping of plaster or expansion of brickwork (unsound).
Hardening depends on combination with carbon dioxide (CO2) from the air (carbonation) with reformation of the original calcium carbonate (CaCO3).

Because hardening is necessarily from the outside, the interior of a mass hardens more slowly, even where a mix includes sand, which makes access of air to the interior somewhat easier.

• High calcium lime is used in mortars, rendering and plasters.
High calcium limes with formulas:

• **Limestone**: $\text{CaCO}_3$ (sometimes it is as $\text{CaCO}_3 + \text{MgCO}_3$)

• Limestone under $900^0\text{C}$ gives calcium oxide + carbon dioxide. This procedure is performed in kilns.
Production of quicklime:

900°C

CaCO₃ → CaO + CO₂

Produced CaO is quicklime

Slaking of lime:

CaO + H₂O → Ca(OH)₂ (Hydrates (slaked) lime).
HYDRATION (SLAKING)

\[ \text{CaO(quicklime)} + \text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2 + \text{Heat} \]

Lime intended to be used in MORTAR is usually slaked in a box.

The mixture of quicklime and water is stirred until a thin paste has been formed. This paste is then placed in a hole (or barrel) in the ground and covered with 5-10 cm thick soil to protect it from the action of air. It's kept in there for SEASONING;

- 1 week for use in mortar
- 6 weeks for use in plaster (appearance important)

*Seasoning* provides homogenous mass and completion of chemical reactions. During slaking heat evolves and volume expands (2.5-3 times).
Hardening of lime:

\[ \text{Ca(OH)}_2 + \text{CO}_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O} \]

**Magnesium Lime:**
These non-hydraulic limes are made from limestone, contain about 20% of magnesium oxide. They slake and evolve less heat than high-calcium limes. The magnesium limes are more plastic and develops a better ultimate strength.

**High Magnesium Lime:**
The limestone of that kind contains more than 25% of magnesium oxide.
Hydraulic Lime:
☞ Hardens by an internal reaction of burning chalk or limestone.

☞ Like all other limes, they must be thoroughly slaked, excess water would lead to premature hardening and the exact amount of water required can only be determined by experience with the particular lime concerned.

☞ It has low strength. So cannot be used as structural material.

☞ Used for ornamental and architectural works.
<table>
<thead>
<tr>
<th>Term</th>
<th>ENV 459-1*</th>
<th>BS 6100 Section 6.1**</th>
<th>ASTM C 51-98***</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air limes</td>
<td>Limes mainly consisting of calcium oxide or hydroxide which slowly harden in air by reacting with atmospheric carbon dioxide. Generally, they do not harden under water as they have no hydraulic properties.</td>
<td></td>
<td>A calcined limestone, a major part of which is calcium oxide in association with magnesium oxide, capable of slaking with water.</td>
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<tr>
<td>Quicklime</td>
<td>Air limes mainly consisting of calcium oxide and magnesium oxide produced by calcinations of limestone and/or dolomite rock. Quicklimes have an exothermic reaction when in contact with water. Quicklimes are offered in varying sizes ranging from lumps to finely ground materials.</td>
<td>A product obtained when calcareous material is heated at a temperature high enough to drive off carbon.</td>
<td>(Dolomitic)-indicates the presence of 35-46% magnesium carbonate (MgCO₃) in the limestone from which the material was formed.</td>
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<tr>
<td>Dolomitic lime</td>
<td>Quicklimes mainly consisting of calcium oxide and magnesium oxide.</td>
<td>Quicklime of high magnesium content.</td>
<td>(Magnesian)-indicates the presence of 5-35% magnesium carbonate (MgCO₃) in the limestone from which the material was formed.</td>
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<tr>
<td>Grey lime</td>
<td>Quicklime made from grey chalk- usually having semi-hydraulic properties.</td>
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<tr>
<td>Magnesian lime</td>
<td>Quicklime containing more than 5% of magnesium oxide</td>
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<td></td>
</tr>
<tr>
<td>Hydraulic lime</td>
<td>Limes mainly consisting of calcium silicates, calcium aluminates and calcium hydroxide produced either by burning of argillaceous limestones and subsequent slaking and grinding and/or mixing of suitable materials with calcium hydroxide.</td>
<td>Quicklime containing sufficient soluble silica, aluminates, etc. to enable it to hydrate and set in the presence of water.</td>
<td>(Hydraulic hydrated lime) the hydrated dry cementitious product obtained by calcining a limestone containing silica and alumina to a temperature short of incipient fusion so as to form sufficient free lime (CaO) to permit hydration, and at the same time, leaving unhydrated sufficient calcium silicates to give a dry powder meeting hydraulic property requirements.</td>
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<tr>
<td>Semi-hydraulic lime</td>
<td>Similar to hydraulic lime but containing less soluble silica, aluminates, etc. (minimum soluble silica usually 6%)</td>
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<tr>
<td>Hydrated lime</td>
<td>Slaked limes mainly consisting of calcium hydroxide</td>
<td>Fine white dry powder, produced by mixing together quicklime and water in controlled quantities, removing gritty material from the resulting product and drying it. The main constituent is calcium hydroxide.</td>
<td>A dry powder obtained by treating quicklime with water enough to satisfy its chemical affinity for water under the conditions of its hydration. It consists essentially of calcium hydroxide or a mixture of calcium hydroxide and magnesium hydroxide or both.</td>
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</tbody>
</table>

Table 2.2 Building limes (Lea`s book)

<table>
<thead>
<tr>
<th>Lime type</th>
<th>CaO + MgO Min&lt;sup&gt;a&lt;/sup&gt; (%)</th>
<th>MgO&lt;sup&gt;a&lt;/sup&gt; (%)</th>
<th>CaO + MgO Min&lt;sup&gt;a&lt;/sup&gt; (%)</th>
<th>MgO&lt;sup&gt;a&lt;/sup&gt; (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium CL 90</td>
<td>≥90</td>
<td>≤5</td>
<td>≥95</td>
<td>≤20</td>
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<tr>
<td>Calcium CL 80</td>
<td>≥80</td>
<td>≤5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium CL 70</td>
<td>≥70</td>
<td>≤5</td>
<td></td>
<td></td>
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<tr>
<td>Magnesium</td>
<td></td>
<td></td>
<td>≥95</td>
<td>≥20</td>
</tr>
<tr>
<td>Dolomitic DL 85</td>
<td>≥85</td>
<td>≥30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dolomitic DL 80</td>
<td>≥80</td>
<td>&gt;5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydraulic</td>
<td></td>
<td></td>
<td>≥65</td>
<td>≤5&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup> Expressed in term of quicklime.


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Total 15

LIMES