**W1.43**

## Proportioning of Raw Materials

1 Chemical Principles

a Hydraulic Modulus ( H.M.)
H.M. = $CaO/(SiO_2 + Al_2O_3 + Fe_2O_3)$
Normal range for O.P.C. – 1.7-2.2

b Silica Modulus or Silica Ratio ( S.M.)
S.M. = $SiO_2/ (Al_2O_3+Fe_2O_3 )$
Normal range = 1.2 – 4.0 ; commonly 2.4-2.7

c Iron Modulus or Iron Ratio (I.M.)
I.M. = $Al_2O_3 / Fe_2O_3$
Normal range = 1-4; commonly 1.5-2.5

d Kuhl's Lime Standard (K)
$K = 100CaO / (2.8SiO_2 + 1.1Al_2O_3 + 0.7Fe_2O_3)$
For O.P.C. , K = 90-95
For Rapid Hardening Cement, K = 95-98

2 Types of lime stone and content of Calcium Carbonate ( $CaCO_3$ )

| Designation of stone | % $CaCO_3$ |
|---|---|
| High grade limestone | 98-100 |
| Marly limestone | 90-98 |
| Lime marl | 75-90 |
| Marl | 40-75 |
| Clayey marl | 10-40 |
| Marly clay | 2-10 |
| Clay | 0-2 |

3 In calcinations process , $CO_2$ is released from carbonates and water of hydration is Driven off from clays.
100 parts $CaCO_3$ = 56 parts CaO + 44 parts $CO_2$
about 7% water is driven off from clay
A raw mix containing 76 parts $CaCO_3$ and 24 parts clay will lose per kg,
0.76*0.44 = 0.3344 kg $CO_2$
and, 0.24* 0.07 = 0.0168 kg water
Therefore total loss of ignition = 0.351kgs. In other words, 1 kg of raw mix
Containing 76 % $CaCO_3$ would yield 0.649 kgs of clinker

For different values of $CaCO_3$ quantities of materials can be calculated as follows :
Let, a = kg of clinker / kg raw meal
Then $a = 1-(0.44* \% CaCO_3/100 + 0.07*(100- \%CaCO_3/100 )$
If b=kg of raw meal / kg clinker, then b= 1/a

If c= % CaO in clinker, then c= %$CaCO_3$*56/ 100*a
For preliminary and broad calculations, it is assumed that 1.55-1.6 kgs of raw meal are required to make 1 kg clinker. Loss of water is ignored.

4 Proportioning of a two component raw mix
let composition of clay and limestone be as follows:

| | ←----------%-------→ | | | | | | |
|---|---|---|---|---|---|---|---|
| | CaO | $CaCO_3$ | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | MgO | L.O.I. | S.M. |
| Limestone | 52.9 | 94.5 | 2.9 | 1.1 | 0.8 | 0.3 | 42 | 1.53 |
| Clay | 4.3 | 7.7 | 50.4 | 22.2 | 8.5 | 2.1 | 12.5 | 1.64 |

Desired raw mix CaO 42.5 and $CaCO_3$ = 76 %

Then,

94.5 → 68.3 ( 76- 7.7)

76

7.7 → 18.5 ( 94.5 – 76)

Proportions of limestone to clay = 68.3 / 18.5 = 3.69
After obtaining the proportions as above, composition of raw mix can be calculated

| | | ←----------%----------→ | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | CaO | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | MgO | L.O.I. | S.M. |
| Limestone | 3.69 | 52.9 | 2.9 | 1.1 | 0.8 | 0.3 | 42 | 1.53 |
| Clay | 1 | 4.3 | 50.4 | 22.2 | 8.5 | 2.1 | 12.5 | 1.64 |
| % in raw mix | | 42.5 | 13.02 | 5.6 | 2.4 | 0.7 | 35.7 | 1.6 |
| Lime standard | | 95.97 | | | | | | |
| Silica modulus | | 1.62 | | | | | | |
| Iron modulus | | 2.3 | | | | | | |
| Hydraulic modulus | | 2.02 | | | | | | |

Which fall within the respective normal ranges of these modulii

More accurate proportioning can be worked out by using Michelis formula

5 Proportioning on basis of CaO content on loss free basis
let x parts of clay be mixed with 1 part of lime; then
x = (CaO limestone – CaO raw mix ) / ( CaO raw mix – CaO clay)
substituting above values, we get limestone /clay = 3.65 same as above.

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source: Ottolabahn Cement Engineers Handbook