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## APPENDIX B - Mortar analysis results

**Date Analysed:** 24/05/17
**Sample:** Mortar from behind Reredos, Mackworth Church
**Observations:** A hard, dark grey coloured, generally thin, fine grained mortar.

RESULTS

| Components of Mortar | Method | Results % by mass | |
|---|---|---|---|
| **Calcium Carbonate %C** | Calcimetry - $CO_2$ emission | **43.6** | |
| **Dolomite %D** | Calcimetry and titrimetric (EDTA) | **0** | |
| **Aggregate** | Gravimetric | **13.3** | |
| **Gypsum** | Barium Chloride | **3.2** | |
| **Nitrates** | Titrimetric/test strips. | **0.2** | |
| **Chlorides** | Titrimetric/test strips. | **0** | |
| **Iron Oxides ($Fe_2O_3$)** | Test strips/Titrimetric ($K_2Cr_2O_7$) | **0.8** | |
| pH of mortar sample | Indicator Strips/pH meter | **10** | |
| **Mix Ratio** by Mass | **Parts Aggregate : Parts Binder** | **0.15 : 1** | |
| **Mix Ratio** by Volume (if binder was lime putty) | **Parts Aggregate : Parts Binder** | | |
| **Mix Ratio** by Volume (if binder was Hydraulic lime or cement) | **Parts Aggregate : Parts Binder** | **0.1 : 1** | |
| **Active lime [$Ca(OH)_2$]** | Titrimetric (Extracted in 10% sugar solution) | **0.01** | |
| **Carbonated lime in binder (degree of Carbonation)** | From %$Ca(OH)_2$ in binder | **99.96** | |
| **Cementitious Compounds** | %S x 2.5 | **38.8** | |
| **Soluble Silica %S** | Volumetric/Titrimetric - (Conversion to silicomolybdic acid) | **15.5** | |
| **Soluble Silica in Original Binder** | From: %S x $\frac{A}{B}$ + 1) | **23.8** | |
| **CaO in Original Binder** | From CaO in mortar | **69.3** | |
| **CaO in Mortar** | Titrimetric (EDTA) Gravimetric (ammonium oxalate) | **45.2** | |
| **Aluminium Oxide in Binder** | Gravimetric (using Oxine) | **-** | |
| **Cementation Index for Binder (CI)** | CI ≈ $\frac{\%S \times 2.5}{(\%C \times 0.56) + (\%D \times 1.5)}$ | **1.5** | |
| **Type of Binder or equivalent strength** | Dependent on the % Soluble Silica in Binder | **Cement (OPC)** | |

A lime putty with 50% moisture by mass is considered in the calculations above. A greater percentage of moisture in the lime putty, gives a higher Aggregate : Binder ratio (by mass and/or volume)

**Methodology:** A variety of specific volumetric, titrimetric, gravimetric and microchemical techniques, in addition to polarised light microscopy, are used to determine the components and characteristics of the mortar sample, as shown in the results table.

| | |
|---|---|
| **Summary of Results and Comments:** | **The acid insoluble (aggregate):** is a fine grained (<0.09mm), light grey coloured silicate ash material (PFA type), which may have been added to increase the set and hardness of the mortar, by virtue of its pozzolanic reaction with free lime in the cement:<br><br>  <br>'aggregate' mag.x 10<br><br>**The Binder:** is a dark grey coloured cement (OPC) possibly grade 3 because of its >21% soluble silica content and high iron content, the latter giving the 'mortar' its dark grey colour.<br><br>**The Mortar:** is essentially a neat cement (OPC), with about 13% grey ash material. |