

## TABLE OF CONTENTS.

## SECTION I.

VARIOUS LIMES, OR AGENTS OF ADHESION IN CALCAREOUS MORTARS AND CEMENTS.

#### CHAPTER I.

Of limestones, and the various limes they furnish.—Distinction of the known limes into rich, poor, and hydraulic limes. Characteristics of the different limes.-Method of distinguishing and classifying them.—Relation between the qualities of limes and the chemical composition of the stones whence they are derived 1 ... ... CHAPTER II. Calcination of limestone on the large scale.—Conditions necessary to render the calcination as easy as possible.—Case of the rich limes.—Case of the hydraulic limes.—Different kilns made use of .-- Average quantity of combustibles required for the calcination of a cubic metre of lime.--Irregular action of the coal kiln by slow heat ... ... ... 13 CHAPTER III. Of artificial hydraulic limes.—Two modes of preparing them. Comparison between the hydraulic limes and the watercements used in England.—Description of the processes followed by M. Saint Leger at Paris.—Average price of the artificial hydraulic limes 20 ... ... ... b

Pages.



ii

#### TABLE OF CONTENTS.

#### CHAPTER IV.

Pages.

#### CHAPTER V.

Of the hydrates of lime, or solids resulting from the simple combination of water and lime.—Influence of the degree of consistency given to the hydrate in the first instance.—Action of the air.—Mode of exhibiting this action.—Action of the water.—Use that may be made of the hydrates in the arts.

21

26

## SECTION II.

VARIOUS INGREDIENTS WHICH UNITE WITH LIME IN THE PREPARATION OF CALCAREOUS MORTARS AND CEMENTS.

#### CHAPTER VI.

Of sands.—Of arenes.—Of psammites.—Of clays.—Of volcanic or pseudo-volcanic pouzzolanas.—Of the artificial products analogous to pouzzolanas.—History of these substances ... 4

#### CHAPTER VII.

Qualities of the ingredients mentioned in the preceding chapter.—Definitions—inert substances—slightly energetic



#### TABLE OF CONTENTS.

iii

Pages.

substances—very energetic ditto.—Insufficiency of their physical characters to denote the qualities specified under the above denominations.—Approximate chemical methods of recognising them; by means of acids, by lime-water ... 52

## CHAPTER VIII.

#### CHAPTER IX.

Mutual suitableness of the ingredients, with the various limes, in relation to the destination of the mortars or cements for the preparation of which we use them.—Case of constant immersion.—Case of alternations of dryness and moisture. Case of exposure to the weather ... ... ... ... ... ...

## SECTION III.

COMBINATION OF THE ELEMENTS OF CALCAREOUS MORTARS
AND CEMENTS.

## CHAPTER X.

Mortars or cements intended for immersion.—Choice of proportions.—They are variable.—Limits established for certain cases.—The proportions exert a more important influence the less energetic the mixed substances are.—They must be modified according to the use for which the mixtures are intended.—Choice of the process of slaking.—Order of pre-

b 2



iv

#### TABLE OF CONTENTS.

eminence of the three known processes, in reference to the nature of the lime made use of.—Manipulation or manufacture.—How it ought to be conducted under various circumstances.—Application to use, or immersion.—Difficulties to be overcome, how to manage them.—Old method defective. Action of the water upon the parts of immersed mortars or cements with which it is in immediate contact.—Influence of time ... ... ... ... ... ... ... ... ... 67

CHAPTER XI.

Mortars or cements constantly exposed to the weather.—Mode of correcting the bad qualities of rich limes.—Use of sand in different mortars.—Opinion of the ancients upon the quality of sands.—Influence of their size—it varies with different limes.—Method of mixing them.—Choice of proportions,—with rich limes,—with hydraulic limes.—Choice of the process of slaking;—it is the same as in the case of immersion.—Fabrication.—Conditions of a good manipulation.—Use—difficulties to be overcome.—How to attain the object.—Precautions in respect to drying to be taken after application.—Very remarkable influence of time upon mortars of rich lime, after many centuries ... ... ... ... ...

CHAPTER XII.

CHAPTER XIII.



#### TABLE OF CONTENTS.

V

#### CHAPTER XIV.

Pages.

Influence of beating upon the resistance of mortars.—Cases in which it is more injurious than useful.—Difficulties which mortar when used as a plastic substance opposes to moulding.—Case in which these difficulties disappear ... ... 106

#### CHAPTER XV.

#### CHAPTER XVI.

## CHAPTER XVII.



vi

TABLE OF CONTENTS.

## APPENDIX.

## NOTES ON CHAPTER I.

No.	P	ages.
1.	History of lime and calcareous minerals	141
2.	Chemical methods of appreciating the qualities of lime-	
	stones.—Fruitless attempts of the ancients in this respect	143
3.	Of the way in which we have been enabled to add to the	
	facts made known in 1818.—Authenticity of the new	
	results	145
4.	On the colour of limes $\dots$ $\dots$ $\dots$ $\dots$ $\dots$ $\dots$ $\dots$ $\dots$	ib.
5.	Method of analyzing a magnesian limestone by hydration	146
6.	Account of the Madras magnesia	147
7.	History of artificial hydraulic limes	150
	NOTES ON CHAPTER II.	
	NOTES ON CHAITER II.	
8.	Effects of calcination on compound limestones.—Mutual	
	re-action of the constituents	152
9.	Influence of aqueous vapour upon the calcination of lime-	102
		ib.
10.	Fact relative to calcination in a close vessel	
	Consequence of the imperfect burning of limestones.	100
	Contradictory experiments on this subject	154
12.	Experiments upon the different quantities of combustibles	101
	used in the burning of lime	157
13.	Sensible improvement which takes place in the burning of	10.
	lime with coal, by very slight modifications in the manage-	
	ment of the fire, and in the selection of the combustible	158
14.	Irregular action of the coal kilns by slow heat (feu	100
	continu).—Use of turf	159
15.	Kilns with alternative fires for the burning of argillaceous	100
	limestone—manner of using them	ib.
	0	10.



## TABLE OF CONTENTS.

vii

	NOTES ON CHAPTER III.	
No.		ages.
16.	Remarkable instances of the use of artificial hydraulic limes	161
17.	Opinion of certain chemists on the efficacy of oxide of	
	manganese in lime and mortars-Striking instance in op-	
	position to that opinion	163
18.	Details of the manufacture of artificial hydraulic lime on	
	the first calcination under the most unfavourable circum-	
	stances	164
	,	
	NOTES ON CHAPTER IV.	
19.	Examination of the vapour and gas disengaged during the	
	slaking of lime	166
20.	Opinions of the masons regarding lime which slakes to	
	dryness	167
21.	History of the various processes of slaking.—Examination	
	of Fleuret's process	ib.
22.	Numerical comparison of the bulks, with the quantities of	
	water absorbed	168
23.	Observations on the quantity of lime contained in equal	
	bulks of the same consistency, of the different hydrates	169
24.	Remarkable fact of the indefinite preservation of rich lime	
	in paste, in damp trenches	ib.
25.	Notes regarding the preservation of limes slaked by im-	
	mersion	170
26.	Repugnance of the workmen to the use of hydraulic lime.	
-0.	Reasons of this repugnance	ib.
27.	Methods made use of at Doué (Maine and Loire) to slake	200
	hydraulic lime, on the large scale and by immersion, and	
	to convey it by the Loire	ib.
28.	Experiment on a large scale on the preservation of quick-	
	lime	171
		-,-
	NOTES ON CHAPTER V.	
<i>o</i> o	Definition of the hydrate of lime by chemists.—How to	
<b>49.</b>	obtain it	ולו
g <sub>O</sub>	Experiments on the absorption of carbonic acid by mortars	
<i>5</i> <b>U•</b>	Experiments on the absorption of carbonic acid by mortals	1/2



viii	TABLE OF CONTENTS.
No.	Page
31.	Progress of carbonic acid in the various hydrates of lime.
	Analyses and remarks 17
32.	Use of unmixed lime in buildings.—Composition of the
	Madras chunam 17.
	NOTES ON CHAPTER VII.
33.	Account of the use of arenes as pouzzolanas 17'
	Of the use of certain psammites as pouzzolanas ib
	Use of pouzzolana by the Romans.—Dutch tarras 178
	Observations of Count Chaptal on the action of sulphuric
	acid on some pouzzolanas 175
37.	Experiment regarding the chemical inaction of lime towards
	quartzDitto upon the inaction of hydraulic lime in the
	same circumstances 180
	NOTES ON CHAPTER VIII.
38.	Account of some artificial pouzzolanas 182
39.	Opinion of certain builders regarding the efficacy of the oxide of iron—invalidated by facts 185
40.	Opinion of Colonel Raucourt, Engineer, upon the influence
	of the contact of the air in the calcination of artificial
	pouzzolanas.—The absorption of oxygen is not sufficiently
	established.—Investigation of the constituent principles of
	pouzzolanas separately mixed with rich lime.—Case in
	which it is impossible to overlook a chemical com-
	bination ib.
41.	Reverberatory furnace proposed for the calcination of
	pouzzolanas—its inconveniences—other forms 186
42.	Experiments of M. Bruyére, Inspector-General of Roads,
	upon artificial pouzzolanas.—Repeated on a large scale
	by M. De Saint Leger 187
13.	Experiment tending to prove that clays calcined in contact
	with the air do not absorb any gas.—The clays which
	are calcined in a close vessel are not acted upon by acids
	to the same degree as those calcined in the air ib.



	TABLE OF CONTENTS.	ix
No.	Pa	ges.
	Research into the influence of the admixture of pure potash or soda with the clays previous to their calcination, in reference to the energy of the artificial pouzzolanas produced	
	NOTES ON CHAPTER IX.	
46.	Explanation of the contradictions exhibited by various writings regarding mortars and pouzzolanas	191
47.	Table of the composition of the various mortars and cements used by Mr. Smeaton	
	NOTES ON CHAPTER X.	
48.	Exceptions offered by the poor limes in relation to proportions	194
49.	Explanation of the influence of the various methods of slaking	ib.
50.	The exception of the hydraulic limes explained	196
	Different ways of viewing cements and mortars	ib
	With reference to their texture and preparation	
	A mode of slaking approved by trial on a large scale	ib.
	The methods of fabrication and immersion approved, by adoption on a large scale in the foundations of the bridge of Charles X. at Lyons	ib
55.	Fatal instance of the use of lime imperfectly slaked	
	Explanation of the deterioration of some water-cements and mortars.—M. Petot's experiments	
57.	Cases of exception applicable to what has been said regarding the influence of time	
	NOTES ON CHAPTER XI.	
	Experiment upon the influence of calcareous sand in comparison with granitic	201
59.	Ancient examples, accidental or designed, in favour of the principles laid down regarding the influence of the coarse-	
	ness of the grain in sands	209



x	TABLE OF CONTENTS.	
No.	I	ages
60.	Ancient examples tending to prove the fatal influence of clay in mortars exposed to the weather	
61.	Explanation of the varied effects of the different methods	
20	of slaking	ib
	Unanimous opinion respecting mortars and cements mixed thin.—Means tried to effect kneading them very stiff	204
63.	Method employed at the canal from Nantes to Brest, to guard the hands of the masons from the action of the	
	lime.—Precautions to be taken relative to the soaking	
	the materials used in masonry	206
64.	The influence of slow drying upon the goodness of mortars known in Italy, and made use of in the fabrication	
		207
65.	Remarkable instance of the time which mortar of rich lime requires to harden.—Chemical comparison of various	
	old and ancient mortars of excellent quality.—Mode of	
	reducing the results of chemical analyses into technical language	000
	language	209
	NOTES ON CHAPTER XIII.	
66.	Observations upon certain cases of deterioration of cements	
	removed from a damp situation to a dry one	212
67.	Compositions for the protection of stuccoes from the	
60	weather	ib.
00.	Effects of frost upon mortars and cements.—Difficulty of explaining them.—Usual mode of experiment.—Remarks	
	on the decay of mortars in the mild climate of India	213
69.	Method proposed by M. Brard to distinguish substances	
	liable to be affected by frost.—Application of that method to various mortars.—Brard's process does not answer	
	with mixtures of this kind;—in respect to bricks and	
	stones it may be of great service	216
	NOTES ON CHAPTER XIV.	
70.	Poor success of Loriot's process applied to mortar consi-	
•••	dered as a plastic substance.—Smeaton's remarks on ditto	219



TABLE OF CONTENTS.

хi

# NOTES ON CHAPTER XV. No. Pages. 71. Account of the English and Russian natural cements. Notice of a cement found in the Madras Presidency NOTES ON CHAPTER XVI. 72. Particulars of the analysis of the cement of the Pyramid of Cheops, by Dr. Malcolmson ... ... ... 222 73. Observations upon certain calcareous incrustations ... ... 224 74. Examples of ancient mortars of great hardness NOTES ON CHAPTER XVII. 75. Particulars of an experiment upon the solidification of the calcined sulphate of lime (Plaster of Paris) ... 76. Experiments upon the solidification of cements composed of rich lime, and artificial pouzzolana ... ... 77. Remarks upon M. Girard's "Notice sur de nouveaux mortiers hydrauliques" ... ... ... • • • TABLES. Account of the manner in which the experiments were made. 234 TABLE No. 1. Comparison of the qualities of various limes with the chemical composition of the limestones from which they are derived... 237 TABLE No. 2. Comparison of the hardness and absolute resistance of compounds, resulting from the combination of water with various ... ... ... 238 limes



xii

## TABLE OF CONTENTS.

TABLE No. 3. (bis.)
Pages The action of muriatic acid upon clays taken in different states,
compared 238
TABLE No. 3.
Comparison of the qualities of ingredients with their behaviour in regard to muriatic acid 240, 241
TABLE No. 4.
Comparison of the various artificial pouzzolanas with the Italian pouzzolana, tarras, and the aqua-fortis cement 242
TABLE No. 5.
Comparison to aid in establishing the reciprocal adaptability of the various limes to the different ingredients of mortars and cements
TABLE No. 6.
Hydraulic mortars and cements compared, in reference to the process of slaking made use of 244, 245
TABLE No. 7.
Comparison of the relative resistances of the various hydraulic mortars and cements, immersed in different states of consistency
TABLE No. 8.
Water-cements and mortars compared in reference to the deterioration which they undergo at their surfaces.—The quickness of set of different cements compared with the varieties of composition of these cements, and the resistance they acquired after one year's immersion



#### TABLE OF CONTENTS.

xiii

## TABLE No. 9.

Pages.

Quickness of set of various cements compared with the proportions and the hardness acquired after one year's immersion 248

#### DOUBLE TABLE No. 10.

Absolute resistance of mortars, compared with that of the hydrates of lime which form their matrix.—Mortars compared in reference to the coarseness of the sand made use of 249

## TABLE No. 11.

Mortars taken from various buildings compared with mortars compounded for experiment from the same limes ... ... 250

## TABLE No. 12.

## TREBLE TABLE No. 13.

Mortars of rich lime compared in reference to the influence of manipulation.—Mortars compared in reference to the consistency given to the mixture of lime and sand.—Mortars compared in relation to the influence of desiccation ... ... 252

## DOUBLE TABLE No. 14.

Absolute resistances of various mortars compared in reference to the effect of beating.—Mortars and cements compared in reference to their specific gravity and their porosity ... ... 253

#### TABLE No. 15.

Characteristics, composition, and absolute resistances of some Roman mortars from the South of France ... ... ... 254



xiv

## TABLE OF CONTENTS.

#