الجمهورية الجزائرية الديمقراطية الشعبية
République Algérienne Démocratique Et Populaire
وزارة التعليم العالي والبحث العلمي
Ministère de l'Enseignement Supérieur et de la Recherche Scientifique
جامعة الشهيد الشيخ العربي التبسي – تبسة
Université Echahid Cheikh Larbi Tebessi – Tébessa
معـــــــــهد المـــــناجم
Institut des Mines
قسم المناجم و الجيوتكنولوجيا
Département Mines Et Géotechnologie

Thesis

Submitted for the Master's degree

Branch: Mining engineering.

Option: MINERAL RESOURCES VALORIZATION.

Control through characterization of the raw material for cement manufacturing at Elma Labiod Cement plant

MOHAMED IKBAL KHENISSI

Before the jury:

LARABA.M	**President**	**M.C.A**	**Echahid Cheikh Larbi Tebessi University - Tébessa**
KRIM.M	**Supervisor**	**M.A.A**	**Echahid Cheikh Larbi Tebessi University - Tébessa**
AOUATI. M.S	**Examiner**	**M.A.A**	**Echahid Cheikh Larbi Tebessi University - Tébessa**

Academic year: 2024/2025

Dedication

To my father, **Khenissi Farid**
Your strength, integrity, and quiet resilience have always inspired me. Thank you for teaching me the value of hard work and perseverance. This accomplishment is as much yours as it is mine.

To my mother, **Chellali Aïda**
Your unconditional love, endless sacrifices, and constant encouragement have been my greatest source of strength. Your belief in me carried me through every challenge.

To my brothers, **Souhaib** and **Adem**, and my sister, **Istabrak**
For your love, laughter, and support throughout this journey. You've always reminded me of what truly matters.

I also dedicate this work
to all those who supported me, near or far
friends, teachers, and family
especially Mr. Krim mansour, my supervisor
and Mr. Aouati slim
my teacher and guider throughout my college career.

Acknowledgments

Before concluding this work, I would like to take a moment to express my deep gratitude to those who, through their presence, love, patience, or guidance, made this journey possible.

First and foremost, I pay tribute to my parents, **Khenissi Farid** and **Chellali Aïda**, the unwavering pillars of my life. Their unconditional love, their quiet but constant support, and their trust in me have been the source of my strength during the most demanding moments.

To my brothers, **Souhaib** and **Adem**, and my sister **Istabrak**, each of whom, in their own way, gave me the courage, the smiles, and sometimes the silence I needed.

To my extended family, I dedicate a heartfelt thank-you for their affection, their prayers, and their pride, which always carried me further.

I would like to warmly thank all my teachers, especially Mr. Krim Mansour, my supervisor, for his trust and guidance, and Mr. Aouati Salim for his invaluable advice and guidance throughout our college career.

To my dear friends, who supported me with their words, their silence, and their presence: **Yassamine Aissaoui**, **Imad Halaimia**, **Touhria Shams**, and **Ammar Bacha**—thank you for your precious friendship, your sincere encouragement, and the moments of sharing that made this path gentler.

To all these generous souls, thank you for surrounding me, inspiring me, and supporting me.

This thesis is not only the result of intellectual effort, but also a reflection of all the human, emotional, and professional connections that have accompanied me on this journey.

Abstract:

Cement production relies heavily on the quality and consistency of its raw materials, mainly limestone, clay, sand and iron ore. At the Elma Labiod cement plant, the need for systematic control of these materials is fundamental to guarantee the production of quality clinker and cement.

This work relies on the use of analytical methods such as X-ray fluorescence (XRF), physical testing and titration to present a detailed analysis of the chemical and mineralogical composition of raw materials and finished products. Monthly compositional trends were monitored and their effects on kiln feed, clinker properties and cement quality assessed. The results show that regular monitoring and rapid correction of proportions can improve product quality and reduce rejection rates.

This work highlights the need to integrate rigorous laboratory analysis and feedback mechanisms into the production chain to maintain process efficiency and meet quality standards. Practical recommendations are made to strengthen the raw materials control system at plant level.

Key words: Cement, raw materials, clinker, X-ray analysis, quality control, Elma Labiod.

Résumé :

La fabrication du ciment repose fortement sur la qualité et la constance de ses matières premières, principalement le calcaire, l'argile, le sable et le minerai de fer. À l'usine de ciment d'Elma Labiod, le besoin d'un contrôle systématique de ces matériaux est fondamental pour garantir la production d'un clinker et d'un ciment de qualité.

Ce travail s'appuie sur l'utilisation de méthodes analytiques telles que la fluorescence X (XRF), les essais mécaniques et la titration pour présenter une analyse détaillée de la composition chimique et minéralogique des matières premières et des produits finis. Les tendances mensuelles de la composition ont été suivies et leurs effets sur l'alimentation du four, les propriétés du clinker et la qualité du ciment ont été évalués. Les résultats démontrent qu'un suivi régulier et une correction rapide des proportions permettent d'améliorer la qualité du produit et de réduire les taux de rejet.

Ce travail met en évidence la nécessité d'intégrer des analyses de laboratoire rigoureuses et des mécanismes de rétroaction dans la chaîne de production pour maintenir l'efficacité du processus et respecter les normes de qualité. Des recommandations pratiques sont formulées pour renforcer le système de contrôle des matières premières à l'échelle de l'usine.

Mots clés : Ciment, matières premières, clinker, analyse X, contrôle qualité, Elma Labiod.

الملخص:

يعتمد تصنيع الأسمنت بشكل كبير على جودة وثبات المواد الخام المستخدمة، والتي تشمل بشكل أساسي الحجر الجيري، والطين، والرمل، وخام الحديد. في مصنع الأسمنت "الماء لبيض"، يُعد التحكم المنتظم في هذه المواد أمرًا أساسيًا لضمان إنتاج كلنكر وأسمنت عالي الجودة.

يرتكز هذا العمل على استخدام تقنيات تحليلية مثل التحليل بالأشعة السينية(XRF) ، والاختبارات الميكانيكية، والمعايرة الكيميائية، لتقديم تحليل مفصل للتراكيب الكيميائية والمعدنية للمواد الخام والمنتجات النهائية. وقد تم تتبّع الاتجاهات الشهرية في تركيبة المواد الخام، وتقييم تأثيراتها على تغذية الفرن، وخصائص الكلنكر، وجودة الأسمنت. وتُظهر النتائج أن المتابعة المنتظمة والتعديل السريع لنسب الخلط يسهمان في تحسين جودة المنتج وتقليل نسب الرفض.

يسلط هذا العمل الضوء على ضرورة دمج تحاليل مخبرية صارمة وآليات تغذية راجعة فعالة ضمن سلسلة الإنتاج، بهدف الحفاظ على كفاءة العملية الإنتاجية والامتثال لمعايير الجودة. كما تم تقديم توصيات عملية لتعزيز نظام مراقبة المواد الخام على مستوى المصنع.

الكلمات المفتاحية: الأسمنت، المواد الخام، الكلنكر، التحليل بالأشعة السينية، مراقبة الجودة، الماء لبيض.

DEDICATION

ACKNOWLEDGMENTS

ABSTRACT

LIST OF TABLES

LIST OF FIGURES

LIST OF DIAGRAMS

LIST OF GRAPHS

GENERAL INTRODUCTION

CHAPTER I : GEOLOGY AND MINING..... 1

I.1 GEOGRAPHICAL CONTEXT..... 1
I.2 GEOMORPHOLOGY 3
I.2.1 The watershed 3
I.2.2 The Miocene Basin 4
I.2.3 Hills..... 4
I.2.4 Wadi beds 4
I.2.5 Springs 4
I.3 GEOLOGICAL OVERVIEW 4
I.1.1 Regional geology..... 4
I.4 TOPOGRAPHY..... 6
I.5 VEGETATION AND HYDROGRAPHY 7
I.5.1 Vegetation cover 7
I.5.2 Hydrography 7
I.6 CLIMATE 8
I.6.1 Precipitation..... 8
I.6.2 Temperature..... 8
I.7 ELMA LABIOD CEMENT COMPANY:..... 8
I.7.1 Geographical location of the company:..... 8
I.8 LOCAL GEOLOGY 9
I.8.1 Geology of the DRAA-EL-BAHI clay deposit 9
I.8.2 Geology of the EL MAL LABIOD limestone deposit.... 9
I.8.3 Geology of the EL MAL LABIOD sand deposit 10

I.9 ELMA LBIOD CEMENT COMPANY 10
I.9.1 Geographical location of the company 10
I.10 EXTRACTION OF RAW MATERIALS 11
I.10.1 Limestone quarry 11
I.10.2 Clay quarry 14
I.10.3 Sand quarry 16
I.10.4 Storage of sand 17
I.10.5 Storage of iron ore 17
I.10.6 Gypsum storage 17
CHAPTER II : WORLDWIDE CEMENT USE AND MANUFACTURE 18
II.1 DEFINITION OF CEMENT 18
II.2 BASIC CONSTITUENTS OF CEMENT 19
II.3 HISTORY 19
II.4 MAIN FIELDS OF APPLICATION 21
II.4.1 CEM I – Portland Cement 22
II.4.2 CEM II – Blended Cement 23
II.4.3 CEM III – Slag Cement 23
II.4.4 CEM IV – Pozzolanic Cement 23
II.4.5 CEM V – Composite Cement 23
II.4.6 White Cement 24
II.4.7 Prompt Natural Cement 24
II.4.8 Fast-Setting Cement 24
II.5 OTHER TYPES OF CEMENT 24
II.5.1 Sulfate-resistant cements: (C.R. S) 24
II.5.2 Colored cements 24
II.5.3 Aluminous cements 25
II.5.4 Masonry cement 25
II.5.5 High-Alumina Cement (HAC) 25
II.5.6 Expansive Cement 25
II.5.7 Low-Heat Cement 26
II.6 ECONOMIC DEVELOPMENT 26
II.7 WORLD CEMENT PRODUCER RANKINGS IN 2024 26

II.8 Main cement manufacturing processes and method 28
II.8.1 Dry manufacturing 30
II.8.2 Semi-dry process 32
II.8.3 Semi-wet process 33
II.8.4 Wet process manufacturing 33
CHAPTER III : CEMENT MANUFACTURING IN ELMA LABIOD CEMENT PLANT. 36
III.1 Crushing 36
III.1.1 Types of crushers used 36
III.1.2 Limestone 40
III.1.3 Clay 40
III.1.4 Additions 41
III.2 -Pre-homogenization 42
III.3 Feeding the raw mill 44
III.4 Raw meal grinding 44
III.5 -Homogenization 46
III.6 -Dust removal 48
III.7 Preheating 48
III.8 Furnace feed 49
III.9 Furnace 50
III.10 Cooler 52
III.11 Transporting clinker 52
III.12 Feeding the cement mill 53
III.13 Cement grinding 54
III.14 Cement storage silos 55
III.15 Shipping cement in bulk and bags 55
CHAPTER IV : MATERIALS & METHODS 59
IV.1 -Raw material laboratory 59
IV.1.1 Limestone pellet X-ray analysis: 59
IV.1.2 Clay pellet X-ray analysis: 63
IV.1.3 Sand pellet X-ray analysis: 66
IV.2 Production laboratory: 70

IV.2.1 ray analysis: *70*
IV.2.2 Preparation of the furnace feed pellet for X-ray analysis in accordance with XQC instruction: *70*
IV.2.3 Preparation of clinker pellets for X-ray analysis according to XQC instructions : *73*
IV.2.4 Preparation of the cement pellet for X-ray analysis according to XQC instructions: *78*
IV.2.5 Determination of rejects with the ALPINE device: .. *83*
IV.3 TITRATION ANALYSIS: 85
IV.3.1 Titration analysis of raw flour: *85*
IV.3.2 Free lime : *85*
CONCLUSION
BIBLIOGRAPHICAL REFERENCES:

List of tables

Table II. 1: Types of cement and fields of application.
Table II. 2: World's leading cement-producing countries in 2024.

Table III. 1: Raw materials crushers.

Table III. 2: Storage Hall.

Table IV. 1: Limestone pellet analysis results for the month of February.

Table IV. 2: Limestone pellet analysis results for the month of March.

Table IV. 3: Limestone pellet analysis results in two months.

Table IV. 4: Clay pellet analysis results for the month of February.

Table IV. 5: Clay pellet analysis results for the month of March.

Table IV. 6: Clay pellet analysis results in two months.

Table IV. 7: Sand pellet analysis results for the month of February.

Table IV. 8: Sand pellet analysis results for the month of March.

Table IV. 12: Sand pellet analysis results in two months.

Table IV. 10: Furnace feed pellet analysis results in February.

Table IV. 11: Furnace feed pellet analysis results in March.

Table IV-12: Furnace feed pellet analysis results in two months.

Table IV. 13: Clinker pellet analysis results for the month of February.

Table IV. 14: Clinker pellet analysis results for the month of March.
Table IV. 15: Clinker pellet analysis results in two months.
Table IV. 16: Cement pellet analysis results for the month of February.
Table IV. 17: Cement pellet analysis results for the month of March.
Table IV. 18: Cement pellet analysis results in two months.
Table IV. 22: Cement quality standards analysis
Table IV. 19: Results of R.F refusal analysis in two months.
Table IV. 20: Cement refusal analysis results in two months.
Table IV-21: Test results for free lime in two months.

List of figures

Fig I. 1: 3D representation of the Elma labiod plain. Using surfer v0.8.

Fig I. 2: Google Earth representation of the Elma labiod plain.

Fig I. 3: Geological map of the EL MA EL ABIOD region. DUROZOY 1948.

Fig I. 4: Geographical location of the company.

Fig I. 5: Limestone quarry - Elma Labiod cement plant - TEBESSA -.

Fig I. 6: Drilling machine.

Fig I. 7: Loading process.

Fig I. 8: Transporting dumper.

Fig I. 9: Clay quarry - Elma Labiod cement plant - TEBESSA -.

Fig I. 10: Sand quarry - Elma Labiod cement plant - TEBESSA-

Fig II. 1: Basic constituents of cement.

Fig II. 2: Drawing of Thames Tunnel as used by foot passengers 1840.

Fig II. 3: World's leading cement-producing countries in 2024.

Fig II. 4: the cement manufacturing process.

Fig II. 5: Dry process for manufacturing cement.

Fig II. 6: Wet process for manufacturing cement.

Fig III. 1: EV crusher.

Fig III. 2: Cylinder crusher E.

Fig III. 3: Double-rotor hammer crusher.

Fig III. 5: Tirax Unidan mill - Elma Labiod cement plant - TEBESSA.

Fig III. 6: Homogenization silos - Elma Labiod cement plant - TEBESSA –

Fig III. 7: Preheating operation.

Figure III. 8: Modern four-stage cyclone furnace. [16]

Fig III. 9: The rotary kiln - Elma Labiod cement plant - TEBESSA -.

Fig III. 10: Clinker storage silos.

Fig III. 11: Batching hopper (clinker, gypsum and additives).

Fig III. 12: Cement storage silos - Elma Labiod cement plant - TEBESSA -.

Fig III. 13: The bagging machine.

Fig III. 14: Shipping cement by bag

Fig III. 15: A bag of cement.

Fig IV. 1: Pelletizer.
Fig IV. 2: X-ray.
Fig IV. 3: Alpine apparatus.
Fig IV. 4: Water bath.

List of diagrams

Diagram III. 1: The crushing process and transport of limestone to the associated hall

Diagram III .2: The crushing process and transport of clay to the associated hall.

Diagram III. 3: The crushing process and transport of additives to the associated hall.

Diagram III. 4: The raw mill feeding process.

Diagram III. 5: The raw milling process.

Diagram III. 6: The homogenization process.

Diagram III. 7: Furnace feeding.

Diagram III. 8: Clinkerization (the furnace).

Diagram III. 9: Feeding the cement grinder.

Diagram III. 10: Shipping cement in bulk.

List of graphs

Graph III. 1: Curve before and after homogenization A and B. [20]

Graph IV. 1: Limestone pellet analysis results for the month of February.

Graph IV. 2: Limestone pellet analysis results for the month of March.

Graph IV. 3: Curve showing the comparison of limestone content in February and March.

Graph IV. 4: Limestone pellet analysis results in two months.

Graph IV. 5: Clay pellet analysis results for the month of February.

Graph IV. 6: Clay pellet analysis results for the month of March.

Graph IV. 7: Curve showing the comparison of clay content in February and March.

Graph IV. 8: Clay pellet analysis results in two months.

Graph IV. 9: Sand pellet analysis results for the month of February.

Graph IV. 10: Sand pellet analysis results for the month of March.

Graph IV. 11: Curve showing the comparison of sand content in February and March.

Graph IV. 12: Sand pellet analysis results in two months.

Graph IV. 13: Furnace feed pellet analysis results in February.

Graph IV. 14: Furnace feed pellet analysis results in March.

Graph IV-15: Curve showing the comparison of furnace feed content in February and March.

Graph IV. 16: Furnace feed pellet analysis results in two months.

Graph IV. 17: Clinker pellet analysis results for the month of February.

Graph IV. 18: Clinker pellet analysis results for the month of March.

Graph IV. 19: Curve showing the comparison of clinker content in February and March.

Graph IV. 20: Clinker pellet analysis results in two months.

Graph IV. 21: Cement pellet analysis results for the month of February.

Graph IV. 22: Cement pellet analysis results for the month of March.

Graph IV. 23: Curve showing the comparison of cement content in February and March.

Graph IV. 24: Cement pellet analysis results in two months.

General introduction

General introduction

Cement is a basic material in modern construction, playing a central role in infrastructure development worldwide. Although cement production stages are now well established, the success of the process is highly dependent on the quality and homogeneity of raw materials such as limestone, clay and sand. A lack of rigorous characterization of these materials can lead to technical malfunctions, increased energy consumption and even non-conformity of the final product.

This thesis focuses on the cement manufacturing process at the Elma Labiod plant, a major unit belonging to the GICA group. It highlights the importance of raw material control and characterization in optimizing the manufacturing process, clinker production stability and cement quality.

The work is structured in four main parts:

- Chapter I: Presents the geographical and geological context of the Elma Labiod region, as well as the quarries and raw materials extraction methods.

- Chapter II: Provides an overview of the cement industry worldwide, its different types, manufacturing processes and areas of application.

- Chapter III: Describes the cement production process at the Elma Labiod plant, following the transformation chain.

- Chapter IV: Describes the experimental methods, material analysis results and interpretations used to assess and ensure the quality of the final product.

CHAPTER I

Chapter I : Geology And Mining

I.1 Geographical context

The ElMa labiod plain is located in the north-east of the country on the Algerian-Tunisian border. about twenty kilometers south of the Wilaya of Tebessa. It covers an area of 478 km2.

It takes the form of a square depression in a mountainous setting with an average altitude of 1,200 to 1,400 m.

This plain is bounded to the north by the Tebessa plain and the Dj.Bouramanne and Dj Doukkane mountains. This axis forms the boundary between two major watersheds: the Medjerdah, which flows northwards, and the Chott Melghir, which flows southwards.

- To the south by Dj Boudjellal and Dj.Ed dalaa;
- To the east by the Algiro-Tunisian border
- To the west by Dj Er-rouisset and Deaa douamiss.

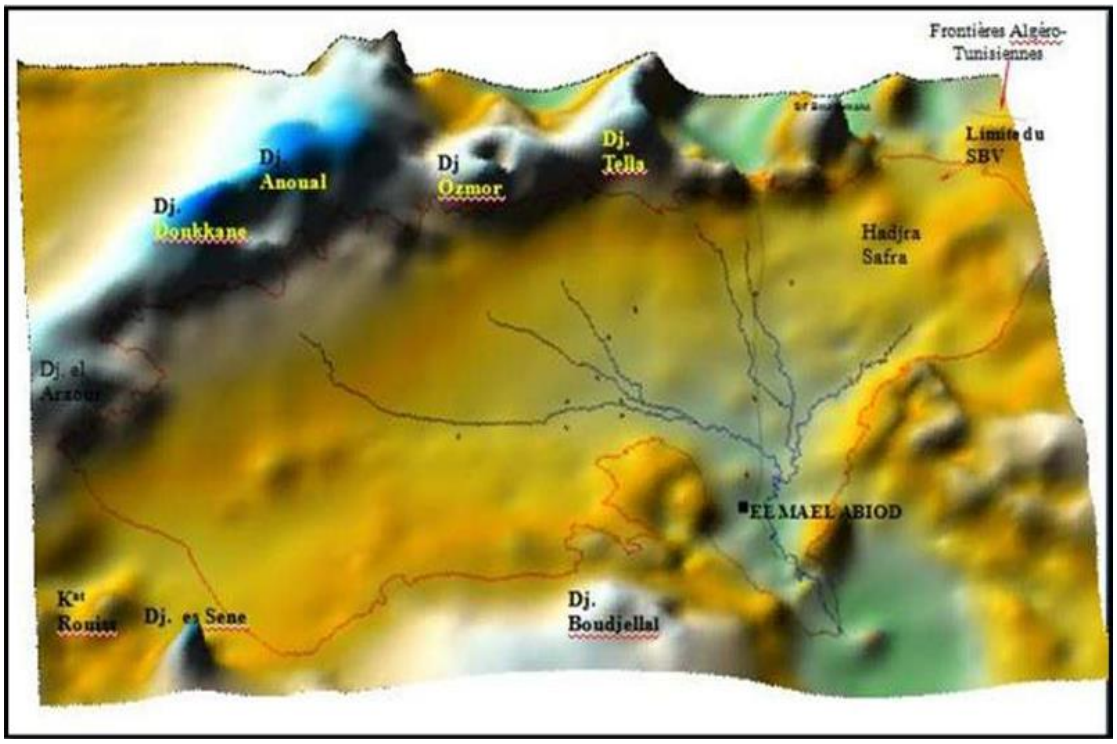


Fig I. 1: 3D representation of the Elma labiod plain. Using surfer v0.8.

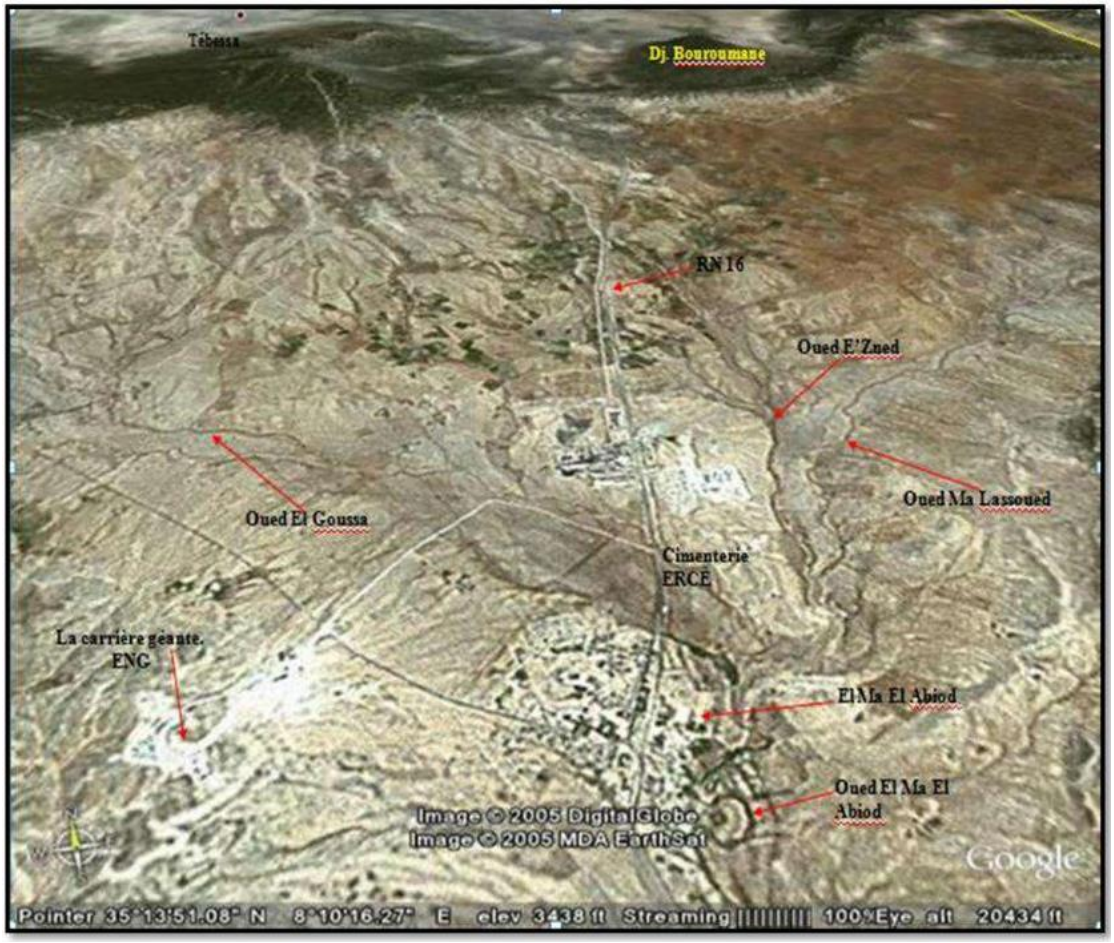


Fig I. 2: Google Earth representation of the Elma labiod plain.

I.2 Geomorphology

In the Elma labiod region, various geomorphological micro and macro forms can be observed, the main ones being:

I.2.1 The watershed

The watershed is essentially made up of Cretaceous formations (Marne, Marno-limestone), which form the ancient base on which the Miocene formations were laid down.

The Cretaceous rocks that make up the watershed are also highly tectonized (faulting and folding).

I.2.2 The Miocene Basin

The Miocene fill formations are made up of red clays, sands and sandstones, overlain by colluvium and alluvium that line the rivers.

I.2.3 Hills

These are geomorphological forms, horsts or remnants of a watershed that has undergone very intense tectonic activity. They appear as “islands” between Miocene formations.

I.2.4 Wadi beds

Wadi beds are the result of erosion. In these dry beds, the terrace and Upper Miocene formations can be distinguished.

I.2.5 Springs

These are mainly located at the contact between the Cretaceous and Miocene fill formations, and are currently dry.

We can also distinguish a major E.N.E -W.S.W elongated rock barrier culminating at over 1550m and continuing for a distance of over 60 km In discontinuity. It is formed by a series of mountain ranges.

I.3 Geological overview

I.1.1 Regional geology

The Elma labiod region lies on the Algerian-Tunisian border and is part of the Saharan Atlas.

The relief is contrasted, consisting mainly of limestone massifs elongated along a SW-NE axis and separated by a depression (Elma labiod cultivated plain) Mio Quaternary. This structure is due to the two tectonic phases that affected the region.

The Elma Labiod plain has not been the subject of a precise geological study, but it is part of a slightly better-known geological complex.

The only drilling and geological surveys carried out since the 1970s have been in search of water and oil.

The plain is gently sloping, bordered to the north and south by SWNE-axis folds.

The northern boundary forms a water divide between two major watersheds: the north-flowing Medjerda and the south-flowing Chotte Melghir.

The sedimentary basin of the Elma labiodh sub-watershed consists of:

- Epicontinental-type deposits with variations in facies and thickness with a SW-NE direction (Aptian to Maastrichtian).
- sandstone and variegated clays of Miocene base.
- Germanic-type Triassic in diapiric form.

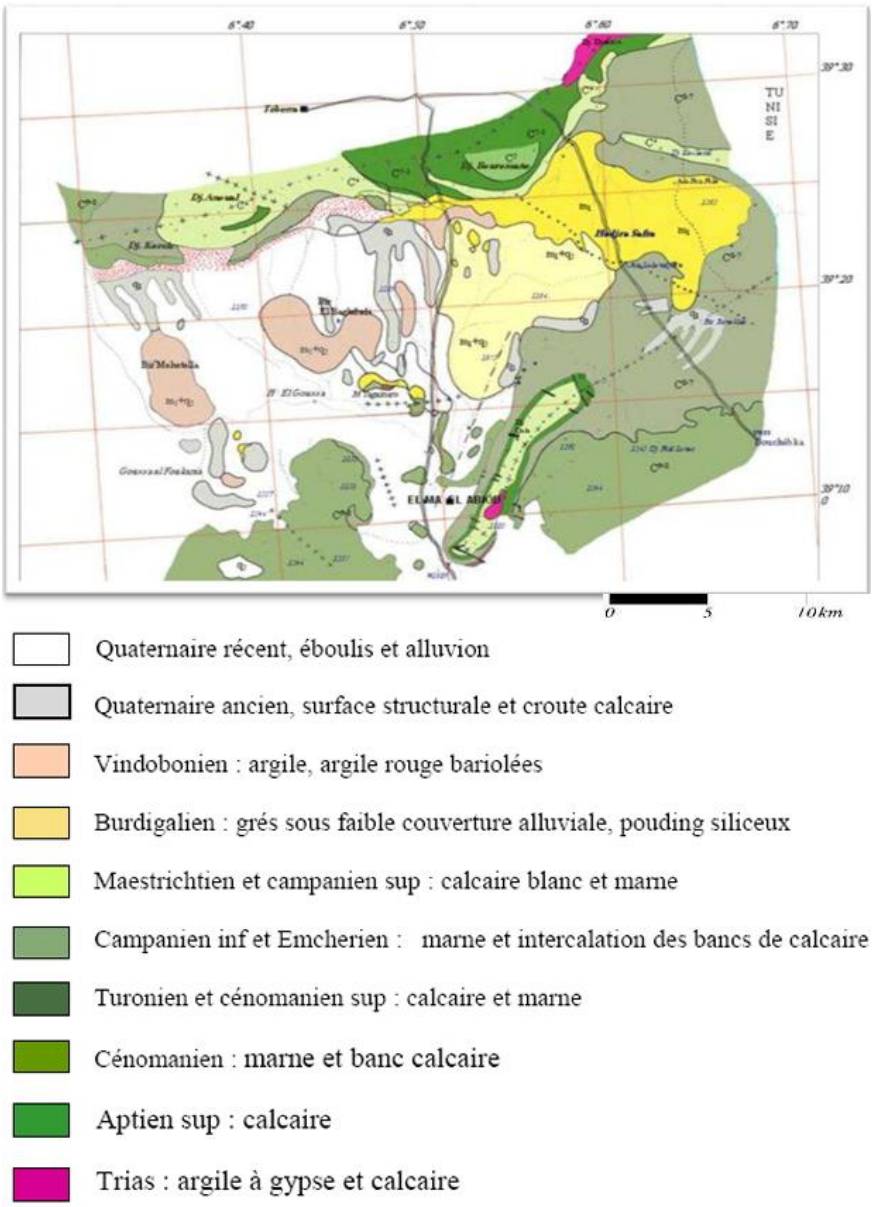


Fig I. 3: Geological map of the EL MA EL ABIOD region. DUROZOY 1948.

I.4 Topography

The Elma labiod region is shaped like a basin, with altitudes ranging from 1,050 m (in the center of the basin) to 1,300 m (the highest peak in the region), and DOUKKANE to the north (1,712 m).

The central part of the region consists of a plain hemmed in by steep mountains to the north and south.

It should be noted that there are a few hillsides in the axis parallel to the national road south of the Oued El Goussa headwaters, with elative heights of between 10 and 20m. in relation to the basin. This is probably due to the rise of impermeable layers (marl). [14]

I.5 Vegetation and hydrography

I.5.1 Vegetation cover

Natural vegetation, based on Aleppo pine, is well-developed in the north of the study area, becoming increasingly sparse towards the south until it disappears at the southern boundary of the Dj-Boudjelal. In contrast to the plains of Mellégue and the mountains of Tébessa, the mountains bordering the Elma labiod plain are characterized first and foremost by the almost total absence of shrubby vegetation, the only real exception being the northern escarpment of the Elma labiod basin, which is covered by a pine forest.

There are also thick junipers on the Dj l'Abiod and especially on the lower southern slopes of the Dj Arour. Everywhere else, rock or soil outcrops between clumps of low steppe dominated by Alfa. [14]

I.5.2 Hydrography

In the Elma labiod region, a number of mountains border the plain in a SW-NE direction. The northern edge (Dj. Doukkane, Dj. Anoual, Dj. Bouroumanne) forms a water divide between Mediterranean and Saharan waters. Generally speaking, the flow is from N to S, 40 m from sea level.

The three main intermittent wadis, which only fill up during the rainy season, are:

- **Oued El Goussa:** runs along the plain from E to W
- **Oued Zanb**: cuts the plain from N to S
- **Oued El Assouad:** runs S-W

These three main wadis converge upstream of the town of Elma labiod to form the Elma labiod wadi, which drains water towards Chotte Melghir. [14]

I.6 Climate

I.6.1 Precipitation

Precipitation is the total quantity of meteoric water, liquid or solid, that falls on a given horizontal surface called the rainfall section.

The Elma Labiod plain is monitored by four rain gauge stations located within the sub-basin. For reasons of convenience, installation of the stations has been limited to the plain. [14]

I.6.2 Temperature

Quantitatively, winter temperatures are colder on the Elma Labiod plain than on the Tébessa plain, since the study plain is located at a higher altitude (1150m on average). On the other hand, summer temperatures are comparable or slightly higher, due to the influence of the south wind (Sirocco). The coldest month is January, while the hottest is July. [2]

I.7 Elma Labiod Cement Company:

I.7.1 Geographical location of the company:

The Elma Labiod cement plant is located 26 km south of Tebessa on National Road N◦ 16, close (100 m) to the Djebel Onk - Tebessa - Annaba railway line.

The cement plant consists of a dry process technology line. It is equipped with a fully automated control system and a computerized technical and administrative management system [1].

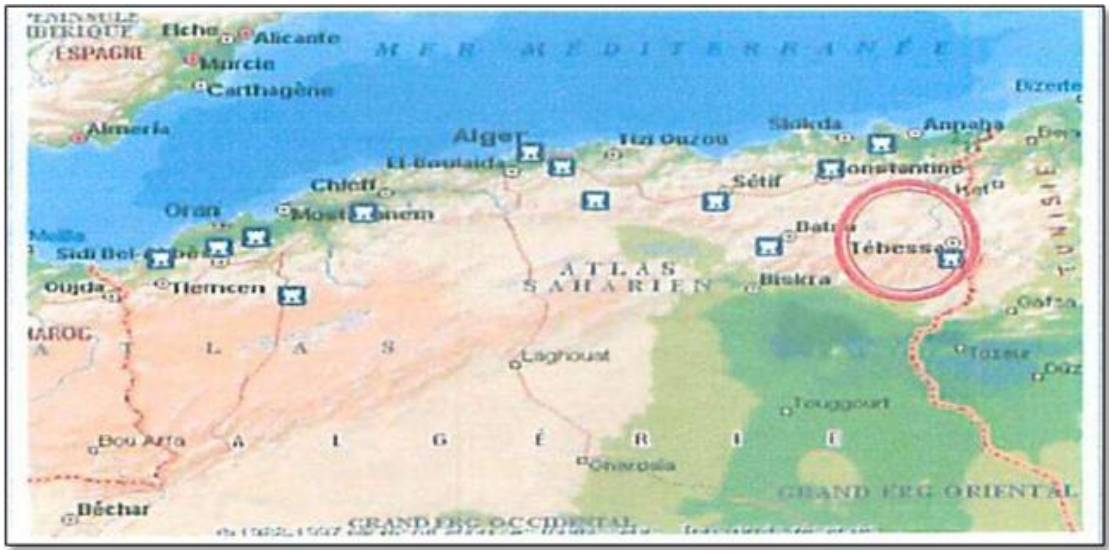


Fig I. 4: Geographical location of the company.

I.8 Local geology

I.8.1 Geology of the DRAA-EL-BAHI clay deposit

A. Location: the DRAA-EL-BAHI clay deposit is the under-dosed material used in the cement works. It is located approximately 18 km south-west of Tebessa. Or 15Km by the national road N° 16.

B. Overburden: the deposit is entirely covered by clay alluvium and limestone crusts, with a thickness of 4m.

C. Useful bedrock: clay with sandstone or sandy interlayers.

- The geological reserves of under-dosed material estimated during the initial geological study are 33,400,000 tons.
- The total volume of cover is: 2,688,952 m3
- Remaining reserves amount to 30,000,000 tons.

I.8.2 Geology of the EL MAL LABIOD limestone deposit

A. Location: it constitutes the cement plant's overbatch and is used in the composition of the raw mix in a proportion of 72 to 75%.

The ELMA LABIOD limestone deposit is located around 10 km from the DRAA-EL-BAHI clay deposit, on the edge of national road N° 16. Less than two kilometers separate it from the village of Elma labiod.

B. Overburden: This covers about 2/3 of the deposit surface, with an average thickness of 1.8 m. The nature of the overburden rocks varies (sand, clayey silts, calcareous crusts).

C. Useful bedrock: Grey to beige limestone in 20 to 40 cm banks, sometimes marly.

- The geological reserves of over-dosed material estimated during the initial geological study are 86,702,000 tons.
- Remaining reserves amount to 75,000,000 tons.

I.8.3 Geology of the EL MAL LABIOD sand deposit

The deposit studied consists of friable soft sandstone. Small sandstone intercalations, 5 to 10 cm thick, are generally concretions of heterogranular quartz crystals strongly cemented with a sandstone matrix. Sandstone color is highly variable.

These sandstones range from fine to coarse. Within these sandstone beds, there are occasional intercalations of sandy clay, clayey sand or alternating sand and clay. These sandstones present a typical criss-cross stratification with alternating beds of various grain sizes, ranging from very coarse to fine.

I.9 Elma Lbiod cement company

I.9.1 Geographical location of the company

Its production unit is designed to produce and sell composite Portland Cement CPJCEM ll/A 42.5 and Special Cement “Sulfate Resistant Cement” or Portland Cement CPACEM I/ 42.5 ES, with an annual capacity of 525,000 tans/year.

I.10 Extraction of raw materials

I.10.1 Limestone quarry



Fig I. 5: Limestone quarry - Elma Labiod cement plant - TEBESSA -.

I.10.1.a. Blasting operations

The blast holes are drilled in one shift per day using a drilling machine with a 110 mm diameter bit. The blasting flight, where the blastholes are to be installed, must be prepared and levelled to allow the drilling machines to move.[13]



Fig I. 6: Drilling machine.

I.10.1.b. Secondary cutting

This operation is carried out on oversize blocks (> 1 m top edge) resulting from blasting, whose dimensions have a negative impact on loading, transport and crushing operations.

This operation calls for maximum reduction of these blocks by optimizing all drilling (geometric) blasting parameters.

To ensure that the operation is carried out correctly, all blocks with an edge greater than 1m are brought together in a special area on the work platforms to be cut together.

Alternatively, if the rock breaker is not available, explosives (Marmanit III is recommended) are used in holes drilled by 36 mm and/or 40 mm diameter hand-held hammer drills. [13]

I.10.1.c. Removal and feeding of the crusher

The quarry uses a loader with a bucket capacity of 7 m^3, which is sufficient for this operation.



Fig I. 7: Loading process.

During the waiting time, the loader proceeds to heap the material and sort out the large blocks for secondary crushing.

The transport operation is carried out by dumpers with a capacity of 40 tons each.



Fig I. 8: Transporting dumper.

The distance between the quarry face and the primary crusher is 700 m. These dumpers are sufficient for material transport. [17]

I.10.2 Clay quarry

I.10.2.a. Extraction work

It should be noted that the loading and transport of useful material during this phase will be carried out in the following stages:

- Discharge of raw material from the platform relief.
- Loading and transport from the active platform.

Based on physical-mechanical properties. Extraction is carried out using a toothed bulldozer.

Two successive operations are required to achieve the qualitative and quantitative objectives.

- **Ripping:** This operation is essential for the preliminary crushing of clayey rock.
- **Discharging:** This is an extension of the first operation, and consists of moving the expanded payload in inclined passes over a distance of no more than 50 meters (to achieve an ideal bulldozer number). [13]



Fig I. 9: Clay quarry - Elma Labiod cement plant - TEBESSA -.

I.10.2.b. Loading

Clay is loaded using a wheel loader with a bucket capacity of 3.5 m^3. A single loader will be sufficient to ensure a daily output of 1023 t/day.

I.10.2.c. Transport

In accordance with the technical task, it is necessary to transport 1071 tons of clay per day from the quarry face to the plant by 20-ton payload trucks. The transport distance from the clay quarry to the cement plant is 18 km on average (round trip). [18]

I.10.3 Sand quarry

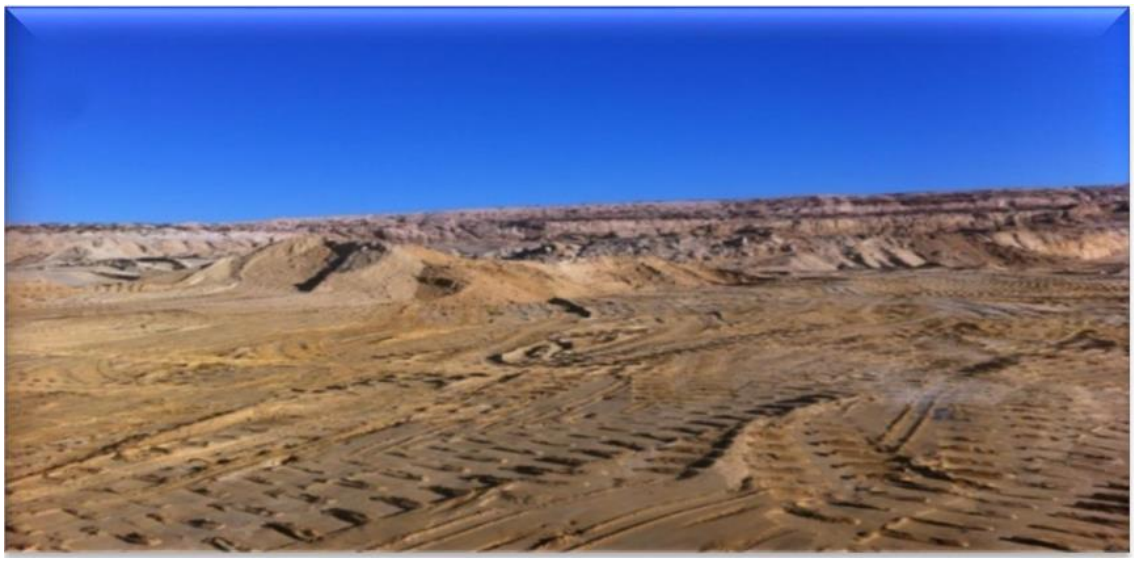


Fig I. 10: Sand quarry - Elma Labiod cement plant - TEBESSA-
.

I.10.3.a. Extraction work

Given its physical-mechanical properties, the sand making up the Elma Labiod deposit is mined using bulldozers and wheel loaders. This mining method is known as “mechanical crushing”. This operation is carried out using a Komatsu bulldozer, which has a sufficient practical daily output. [13]

I.10.3.b. Loading

Sand is loaded using a 5 m^3 capacity bucket loader. A single loader will be sufficient to ensure a daily output of 795 t/day. [13]

I.10.3.c. Transport

In accordance with the technical specifications, 795 tons of sand per day will be transported from the quarry face to the storage area near the cement production unit by 15-ton payload trucks. The average transport distance from the sand quarry to the cement plant is 10 km (round trip). [13]

I.10.4 Storage of sand

The raw material is stored in a location close to the production unit and at a distance of 5 km from the quarry, whose unit has a permanent stock of 20,000 tons to meet the cement plant's demand at all times and avoid any unexpected shortage of sand supplies. [19]

I.10.5 Storage of iron ore

From SOMIFER's BOUKADRA deposit (TEBESSA).

I.10.6 Gypsum storage

This material is supplied by Batna company, a subsidiary of the GICA group, which is 240 km from the plant.

Chapter II

Chapter II : Worldwide cement use and manufacture

II.1 Definition of cement

Cement is a powdery material which, with water or a salt solution, forms a plastic binding paste capable of agglomerating and hardening various substances. Its most common use is as a powder, used with water to aggregate sand and gravel (aggregates) to make concrete. As a physical definition, cement is a hydraulic binder in the form of a fine powder made from limestone and clay, set by adding water. It hardens rapidly, reaching maximum strength in just a few days. Once hardened, the paste retains its strength and stability, even under water.

From a mineralogical point of view, cement can be defined as a mixture of basic oxides, CaO noted C, and acidic or amphoteric oxides such as SiO_2, noted S, Al_2O_3 noted A, or Fe_2O_3 noted F, in cement notation.

We can also give a chemical definition to this material: in this case, artificial cement is a product resulting from the firing of artificial mixtures of silica, alumina and calcium carbonate (lime), on which water has no action (or only a particularly slow action prior to trituration), and which are mechanically reduced to powder.

Cement is a hydraulic binder, meaning it is capable of setting, hardening and developing resistance in both air and water.

Concrete is a composite geomaterial, composed essentially of cement, water and aggregates.

A paste = cement + water.

Mortar = Cement + Water + Sand.

Concrete = Cement + Water + Sand + Gravel. [3]

II.2 Basic constituents of cement

In theory, Portland cement can be made from any material containing lime, silica, alumina and iron. In practice, however, the possibilities are much more limited, since for obvious reasons we have to choose raw materials that are easy to extract, process and combine. By-products from other industries, such as blast-furnace slag or ash from thermal power plants, can also be used as additives. [3]



Fig II. 1: Basic constituents of cement.

II.3 History

Hydraulic cements were first invented by the Egyptians, then improved by other civilizations using lime. Later, the Greeks reinforced it with pozzolanic ash, a use taken up by the Romans. Portland cement" is the material of the 20th century.

In 1818, Frenchman Louis Vicat demonstrated that hydraulic lime could be artificially produced by mixing limestone and clay. This process had the advantage of enabling cement to be made from more common materials.

The Scotsman Joseph Aspidine was the first to take out a patent in 1824, on the manufacture of a binder from a mixture of lime and clay, which he called 'Portland cement'. The term “Portland” comes from the name of the quarry from which the components used by Aspidine came, and is related to hydraulic lime, of which it represents a considerable improvement.

1835, Issac-Charles Johnson, working in a cement factory, observed that overcooked lumps produced better cement after grinding, He increased the firing temperature, giving rise to true portland cement.

In 1838, William Aspdin produces Portland cement by the Thames and convinces Brunel to use it to repair his Thames Tunnel - the 1st use of Portland cement in civil engineering.

In 1845, Johnson established the correct proportions and temperatures, marking the beginning of the Portland cement industry as we know it today. [3]

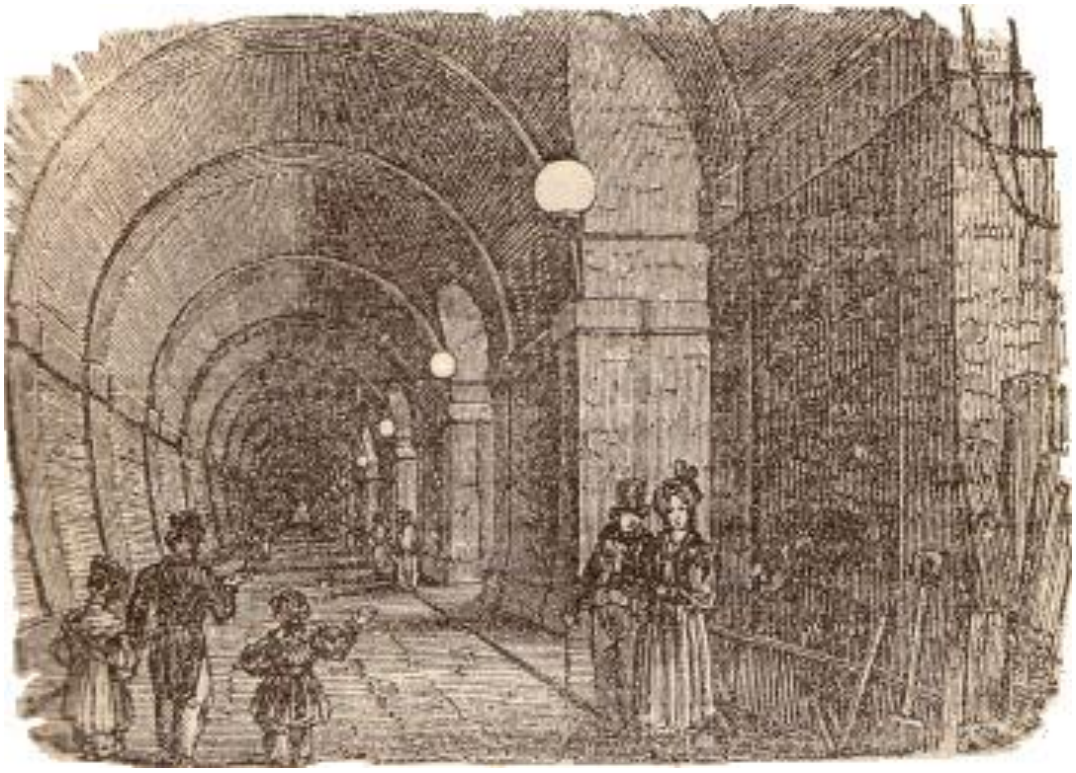


Fig II. 2: Drawing of Thames Tunnel as used by foot passengers 1840.

II.4 Main fields of application

Table II. 1: Types of cement and fields of application.

Sector	Uses	Types of Cement Used	Exemples
Building Construction	Concrete for foundations, walls, slabs, beams	CEM I (Portland), CEM II (Blended)	Houses, schools, hospitals, apartment buildings
Public Works & Infrastructure	Roads, bridges, tunnels, airports, dams	CEM III (Slag), CEM V (Composite)	Highways, metro lines, viaducts

Hydraulic & Marine Works	Structures in water environments	CEM III, CEM IV (Pozzolanic)	Dams, ports, canals, sea walls
Industrial Applications	Flooring, tanks, machine bases	CEM I 52.5 (High-strength), Refractory Cement	Factories, warehouses, chimneys
Landscaping & Decoration	Decorative concrete, prefabricated outdoor elements	White Cement, Prompt Cement	Terraces, urban benches, fountains, decorative façades
Prefabricated Products	Blocks, pipes, paving stones, curbs	CEM I, CEM II	Concrete blocks, fence panels, drainage pipes
Repairs & Sealing	Quick fixes, anchoring, crack repairs	Prompt Cement, Fast-setting Cement	Emergency repairs, underwater anchoring, sealing joints

II.4.1 CEM I – Portland Cement

CEM I, also known as Portland Cement, is produced by heating a finely ground mixture of limestone and clay in a rotary kiln at around 1450°C. This process results in the formation of clinker, which is then cooled and ground with a small amount of gypsum to control setting time. It is the most commonly used cement in the world due to its strength and versatility. [6]

II.4.2 CEM II – Blended Cement

Blended cement (CEM II) involves mixing clinker with supplementary materials such as fly ash, limestone, or slag. After clinker is produced in a kiln as with CEM I, these additions are ground together with the clinker to enhance specific properties like durability and environmental sustainability.[7]

II.4.3 CEM III – Slag Cement

CEM III is produced by blending clinker with a high proportion of ground granulated blast furnace slag. This slag, a by-product from steel production, is rapidly cooled and then finely ground with clinker. The resulting cement has high sulfate resistance and lower heat of hydration, making it suitable for large-scale and marine structures.[7]

II.4.4 CEM IV – Pozzolanic Cement

Pozzolanic cement (CEM IV) is created by grinding clinker with pozzolanic materials such as volcanic ash or natural soil minerals. These materials react with calcium hydroxide during hydration, forming additional cementitious compounds, which improve durability and reduce permeability.[8]

II.4.5 CEM V – Composite Cement

CEM V, or composite cement, combines clinker with both slag and pozzolanic materials. This multi-blend cement benefits from the individual properties of each additive, offering improved chemical resistance, strength, and sustainability. It is manufactured by intergrinding all components together.[7]

II.4.6 White Cement

White cement is made using raw materials with very low iron and manganese content. It is manufactured similarly to Portland cement but under tightly controlled conditions to prevent coloring. The clinker is cooled rapidly and then ground to achieve a bright white finish, used primarily for architectural or decorative applications.[8]

II.4.7 Prompt Natural Cement

Prompt natural cement is made by firing argillaceous limestone at relatively low temperatures (800–1200°C). The calcined material is then ground without additives. This type of cement sets quickly and is particularly valued in restoration work and quick-setting applications.[9]

II.4.8 Fast-Setting Cement

Fast-setting cement is produced by modifying the raw mix to increase the content of tricalcium aluminate (C_3A) and grinding the material more finely. Chemical accelerators may be added to enhance early strength. This cement is ideal for urgent repair works and cold weather concreting.[10]

II.5 OTHER TYPES OF CEMENT

II.5.1 Sulfate-resistant cements: (C.R. S)

C_3S content must not exceed 50%, C_3A content must not exceed 5% and the sum of C_3A and C_3AF must not exceed 22%.

II.5.2 Colored cements

These cements are obtained by adding light- and alkali-resistant mineral colorants to white clinker during cement grinding.

Examples include ultramarine blue, chromium oxide and lampblack.

II.5.3 Aluminous cements

Aluminous cement is a hydraulic binder obtained by firing a mixture of bauxite and lime. These cements are manufactured without additives, or sometimes in very limited quantities.

2% maximum to improve certain properties. They are used for work requiring high mechanical resistance in a very short time (beams and lintels for the building industry, industrial floors, etc.).

II.5.4 Masonry cement

This cement contains, in lesser proportions, the same active elements as artificial portland cement; its properties and behavior in common environments are similar to the latter. However, its strengths are lower than those of portland cement. They are ideally suited to the manufacture of mortars used in building work (masonry, rendering, plastering, etc.). They can also be used to manufacture or reconstitute artificial stone.[5]

II.5.5 High-Alumina Cement (HAC)

Produced by fusing a mixture of bauxite and limestone in a reverberatory or electric furnace at temperatures between 1,500°C and 1,600°C. The molten product is cooled and then ground into a fine powder. This cement is known for its rapid hardening properties and high resistance to chemical attacks.

II.5.6 Expansive Cement

Manufactured by adding expansive agents like calcium sulfoaluminate to the clinker during grinding. These agents cause the cement to expand slightly upon hydration, counteracting the

shrinkage that occurs during drying and setting. This property is beneficial in applications where shrinkage cracking must be minimized.

II.5.7 Low-Heat Cement

Formulated by reducing the content of tricalcium aluminate (C_3A) and increasing the proportion of dicalcium silicate (C_2S) in the clinker. This composition results in a slower rate of heat evolution during hydration, making it suitable for massive concrete structures like dams where thermal cracking is a concern.

II.6 Economic Development

The presence of a cement plant in a given region contributes to the vitality and balance of its development, in economic, social and societal terms. A cement plant thus generates direct and indirect employment, and encourages the establishment and maintenance of companies whose activities are linked to its own. Since the 1970s, for example, it has been deploying the principle of the circular economy through material and energy recovery, thus helping to establish a local value chain.

II.7 World cement producer rankings in 2024

China largely dominates the global cement market with 1900 million tons, producing more than half of the world's total output. India follows with 450 million tones and Vietnam with 110 million tones., although their production is significantly lower. In fourth place is the United States, with cement production of 86 million tons.

Turkey ranks 5th with 82 million tons, followed by Iran with 72 million tons, Brazil with 68 million tons and Indonesia with 65 million tons.

In the TOP 10 of the world's leading cement-producing countries in 2023, Russia also ranks 9th with 65 million tons.

South Korea closes the podium with 52 million tons.[4]

Table II. 2: World's leading cement-producing countries in 2024.

Countries	Production (million tons)
China	1900
India	450
Vietnam	110
United States	86
Turkey	82
Iran	72
Brazil	68
Indonesia	65
Russia	65
South Korea	52

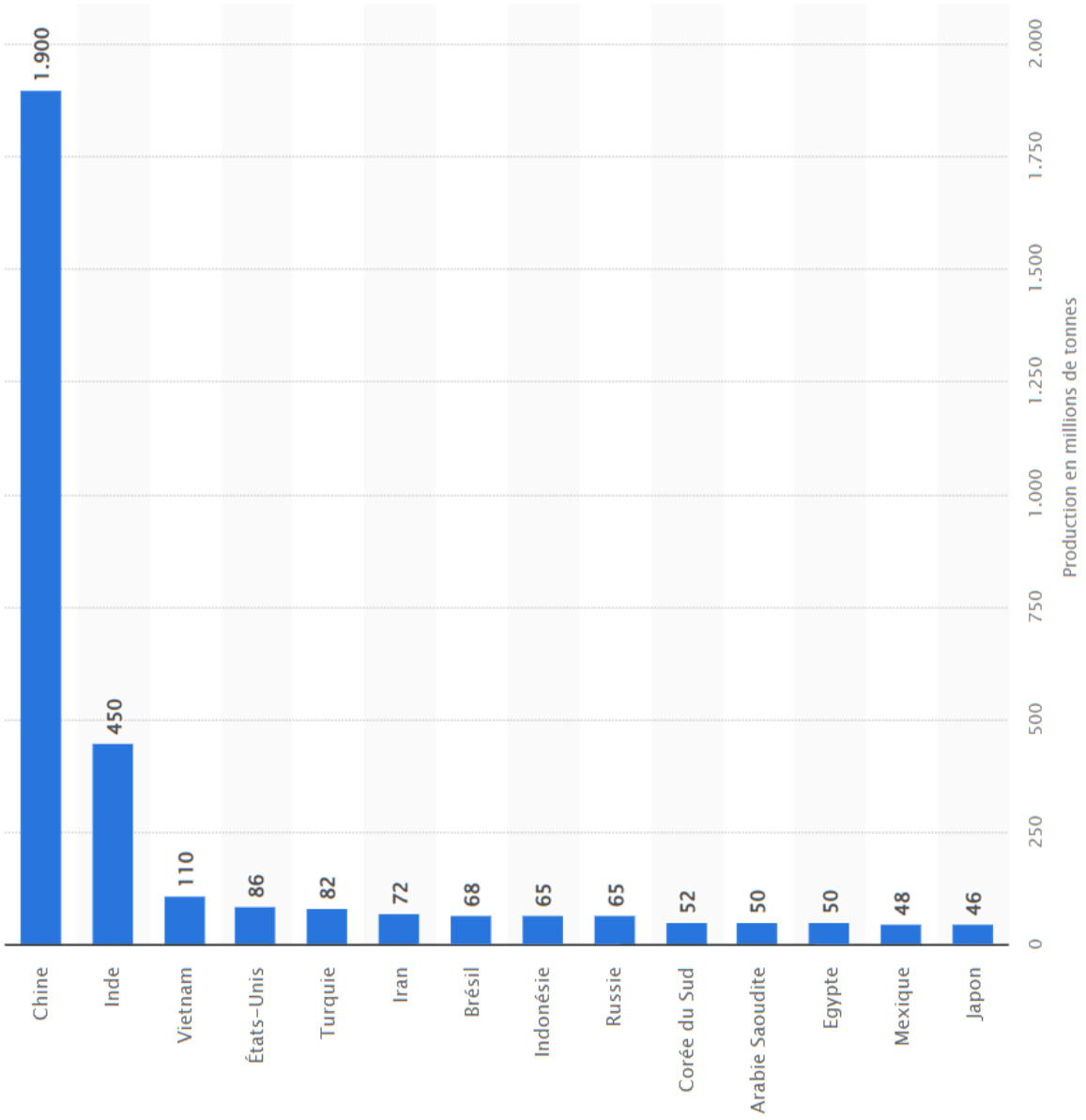


Fig II. 3: World's leading cement-producing countries in 2024.

II.8 Main cement manufacturing processes and method

The manufacture of cement can be schematically reduced to the following three operations:

- raw meal preparation.
- Firing.

- grinding and packaging.

There are four methods of cement manufacture, depending essentially on the material:

- Wet process (the oldest).
- Semi-wet process (based on the wet process).
- Dry cement manufacture (the most widely used).
- Semi-dry cement production (starting from the dry process).

The basic composition of today's cements is a mixture of calcium silicates and aluminates resulting from the combination of lime (CaO) with silica (SiO_2), alumina (Al_2O_3) and iron oxide (Fe_2O_3). The necessary lime is supplied by limestone, and the alumina, silica and iron oxide by clay. These materials are found in nature in the form of limestone, clay or marl and contain, in addition to the oxides already mentioned, other oxides and in particular Fe_2O_2, ferric oxide.

The principle of cement production is as follows: limestone and clay are extracted from quarries, then crushed, homogenized and heated to a high temperature (1450°C) in a kiln. The product obtained after rapid cooling (quenching) is clinker.

A mixture of clay and limestone is introduced into a slightly inclined rotary tubular kiln heated by a flame at around 2,000°C. This flame is fed by various solid, liquid or gaseous fuels. The material gradually heats up on contact with the hot gases. At the inlet, the temperature of around 800°C causes the dehydration of clays and the decarbonation of limestone to produce lime (CaO). Lime then combines with alumina and iron oxide to form calcium aluminates and aluminoferrites, and with silica to form dicalcium silicate (belite). As the temperature of the material rises towards

the flame, aluminates (1,450°C) and aluminoferrites (1,380°C) melt, and the formation of this liquid phase encourages the formation of tricalcium silicate from dicalcium silicate and the remaining lime. It is the hydration of this phase that provides the bulk of the strength in Portland cement concrete.

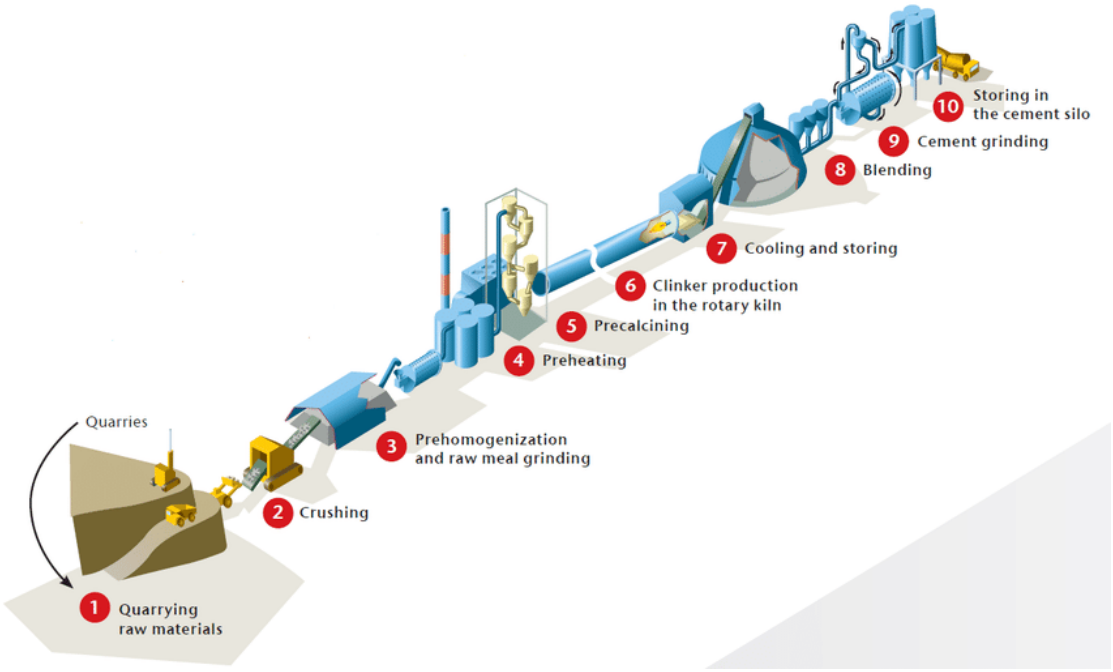


Fig II . 4: the cement manufacturing process.

II.8.1 Dry manufacturing

Conventional cements are made from a mixture of limestone ($CaCO_3$,) approx 80% and clay (SiO_2-Al_2O_3) approx 20%. Depending on the origin of the raw materials, this mixture may be corrected by the addition of bauxite, iron oxide or other materials providing the required alumina and silica complement.

After being finely ground, the powder (flour) is transported from the homogenization silo to the kiln, either by pump, hovercraft and then by aerolift or elevator.

Kilns are made up of two parts:

- the fixed vertical structure: the preheating tower, comprising cyclones and heat exchangers.
- the kiln or rotating section.

The gases heat the raw flour, which circulates in the cyclones in the opposite direction, by gravity. As the flour heats up above around 800°C, it (partially) decarbonates, releasing carbon dioxide (CO_2) and water. The hot flour then enters the rotating section, similar to that used in the wet process, but much shorter.

The dry process poses major technical challenges for manufacturers:

For the possible segregation of clay and limestone in preheaters. In fact, the system used seems to be harmful and, in fact, is used elsewhere to sort particles. In the case of cement production, this is not the case. The powder remains homogeneous, which can be explained by the fact that clay and limestone have the same density (2.70 g/cm³). What's more, the equipment has been designed with this in mind and every precaution has been taken.

The dust problem. This problem is made all the more acute by the draconian conditions imposed by the public authorities, who are highly sensitive to the problem of nuisance. This obliges manufacturers to install dust collectors, which considerably increases the plant's investment costs.

The dust collectors used to treat kiln gases are

- electrostatic precipitators (ESPs): these are made up of a grid of metal wires under high electrical voltage, onto which grains of ionized dust are deposited. These dust grains agglomerate and, under the action of vibrators or hammers that shake the wires, fall back to the bottom of the dust

collector, where they are recovered and returned to the furnace. Apart from breakdowns, these devices have efficiencies of the order of 99%, but absorb a significant proportion of the cement plant's capital equipment.

- bag filters.

The problem of raw material homogeneity is a delicate one. We have seen how it can be solved by pre-homogenization followed by homogenization.

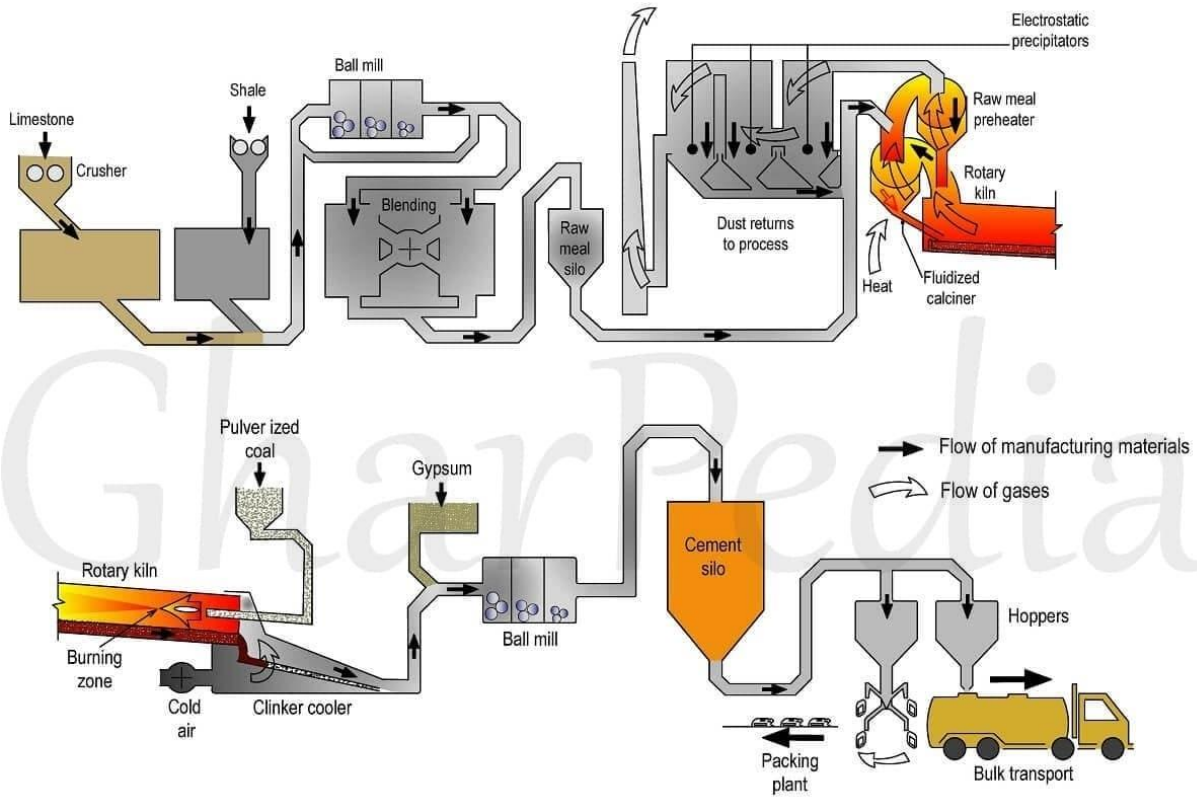


Fig II. 5: Dry process for manufacturing cement.

II.8.2 Semi-dry process

The powder is agglomerated into pellets 10 to 20 mm in diameter by adding 12 to 14% water, dried and preheated in a “Grille LEPOL” chamber and then in the oven.

II.8.3 Semi-wet process

The paste is first dewatered in filter presses. The filter press cake is then extruded in pellet form and fed into a grate preheater or directly into a dryer for raw meal production.

II.8.4 Wet process manufacturing

This process has been around for a long time. It is the oldest, simplest and most energy-intensive process.

In this process, limestone and clay are mixed and finely ground with water to form a fairly liquid paste (28 to 42% water). This paste is vigorously stirred in large basins 8 to 10 m in diameter, in which a merry-go-round of harrows turns.

The paste is then stored in large basins of several thousand cubic meters, where it is continuously kneaded and thus homogenized. This mixture is called the raw meal. Chemical analyses are used to check the composition of the paste, and make any necessary corrections before firing.

The dough is then sent to the entrance of a rotary kiln, heated at its end by an internal flame. A slightly inclined rotary kiln consists of a steel cylinder up to 200 meters long. Inside the furnace, several zones can be distinguished, of which the three main ones are:

- Drying zone.
- Decarbonation zone.
- Clinkerization zone.

The walls of the upper part of the kiln (drying zone - around 20% of the kiln's length) are lined with marine chains to increase heat exchange between the paste and the hot parts of the kiln. On

leaving the kiln, the clinker passes through coolers (clinker quenching), of which there are several types (grate cooler, balloon cooler).

The quenching speed has an influence on the properties of the clinker (vitreous phase).

In any case, whatever the manufacturing method, the same clinker is still hot at around 600 to 1,200°C when it comes out of the kiln. This clinker needs to be finely and evenly ground with around 5% $CaSO_4$ gypsum to “regularize” the setting.

Grinding is a delicate and costly operation, not only because clinker is a hard material, but also because even the best mills have deplorable energy yields.

Ball mills are large, almost horizontally arranged cylinders, half-filled with steel balls, which are rotated rapidly around their axis (20t/mn) and the cement reaches a high temperature (160°C), requiring the mills to be sprayed from the outside. Clinker with a certain percentage of gypsum is fed into the upper part, and the powder is recovered from the lower part.

In open circuit grinding, the clinker passes through the mill only once. In closed-circuit grinding, the clinker passes rapidly through the mill and is then sorted in a cyclone at the outlet. The purpose of grinding is to reduce the clinker grains to powder, and to add gypsum (around 4%) to regulate some of the Portland cement's properties (setting and hardening time).

On leaving the mill, the cement has a temperature of around 160°C, and before being transported to storage silos, it must pass through a centrifugal cooler to keep the cement's temperature at around 65°C.

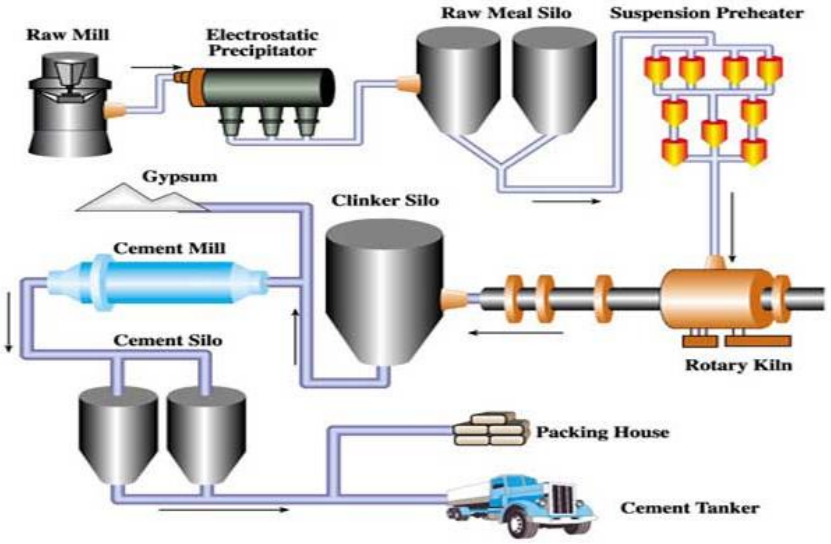


Fig II. 6: Wet process for manufacturing cement.

Chapter III

Chapter III : Cement Manufacturing In Elma Labiod Cement Plant.

III.1 Crushing

III.1.1 Types of crushers used

Table III. 1: Raw materials crushers.

Désignations.	Types and capacities.	Photos.
Limestone crusher N°02.	EV Hammer 200×200 500t/h.	
Clay crusher N°03.	cylinder 120×150 300 t/h	
Addition crusher N°06.	Double hammer rotor 160×150 100 t/h.	

III.1.1.a. EV crusher

This hammer crusher is the largest in the FLS crusher range. It is supplied as a single-stage crusher, reducing stone pieces from 2.5 m to 25 mm. There's no need for an inlet screen, as this type of crusher is equipped with a shock-absorbing cylinder

immediately after the inlet and a thick belt of heavy chains that prevent stone pieces from bouncing off the inlet.

Like all other types, the EV crusher is suitable for crushing non-abrasive, non-sticky hard materials, especially limestone. But it's not as sensitive to moisture and material sticking to the feed.

The EV crusher works with a single set of rotors. The outlet grid of this crusher is constructed from a single removable piece, consisting of grid bars mounted between two stringers. The grid can be clamped against the rotor to compensate for wear. [13]

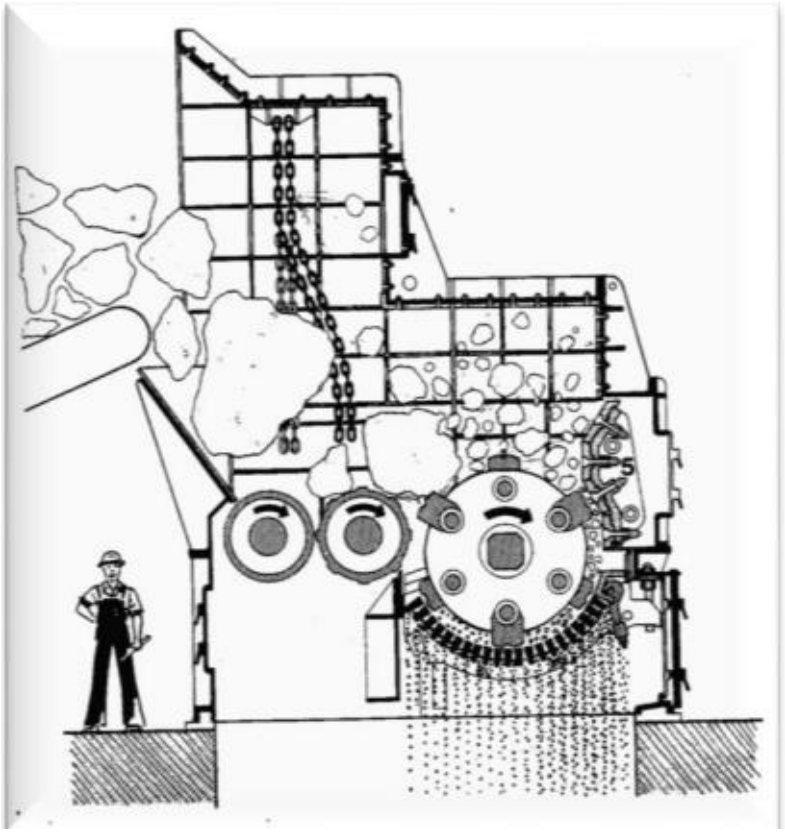


Fig III. 1: EV crusher.

III.1.1.b. Cylinder crushers

Roller crushers are used for the reduction of soft, sticky and moist quarry materials, such as clay. [16]

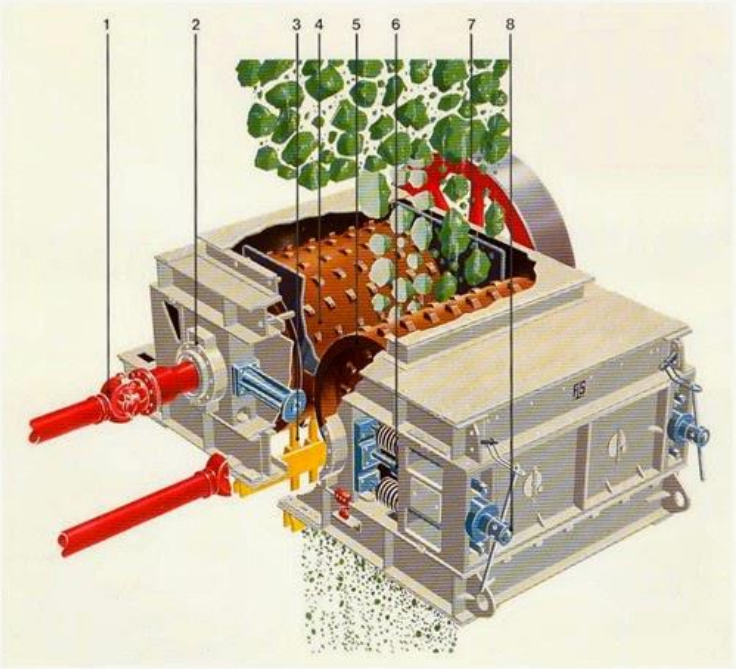
The FLS E-type roller crusher consists of two rollers with molded bosses. One of the cylinder shafts is adjustable, while the other is fixed and fitted with a flywheel.

The gap between the two cylinders varies according to the degree of crushing required. Both cylinders are fitted with scrapers to scrape sticky material from the surface. The equipment is designed to prevent the risk of overloading: a punch-holder device is connected to the adjustable cylinder bearing in conjunction with a motor safety switch. In the event of an extremely hard object being jammed between the cylinders, the punching device will switch on and stop operation of the crusher and feeder.

The motor's power is transmitted via a double gear drive and two drive shafts to allow adjustment of the gap between the cylinders.

The double gear drive ensures synchronized speed of both cylinders.

This increases crushing efficiency and reduces wear.



1. drive shaft.

2.roller bearing

3.scraper.

4.fixed cylinder

5.adjustable cylinder

6.overload protection system.

7.handwheel

8.gap adjustment.

Fig III. 2: Cylinder crusher E.

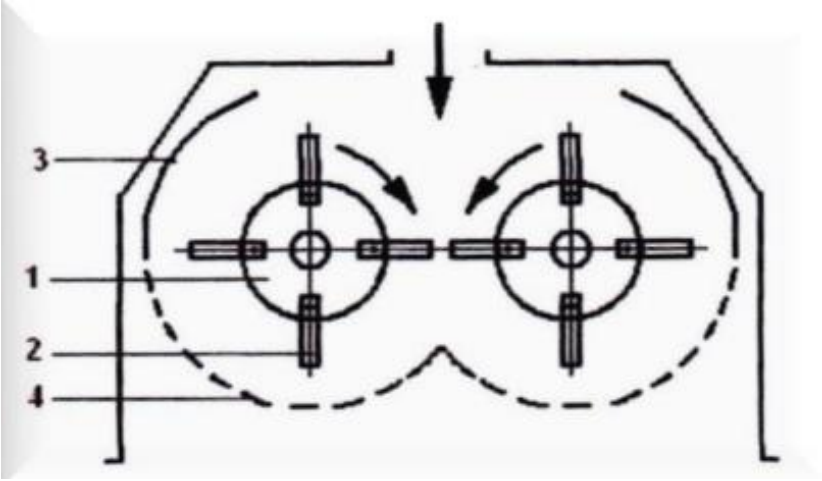
III.1.1.c. Double rotor hammer crushers

Double rotor hammer crushers are actually secondary crushers, but their robust, heavy-duty design makes them well suited to primary crushing of friable materials such as limestone, gypsum and raw coal.

FLS hammer crushers with outlet grid are available with peripheral speeds suitable for both primary and secondary crushing, and can be adapted to handle a variety of raw materials. The slot spacing in the discharge screens can be adapted to the operating conditions in question.

The rotor shafts are fitted with discs on which the hammers pivot. The rotor shafts rotate in bearing rollers that are heavily immersed in oil baths, and rest on the crusher hood made of a heavy iron alloy with sections welded and bolted together. The hood is covered with replaceable wear plates.

The double-hammer crusher features a heavy anvil with replaceable cover plates and an outlet grid: both parts can be adjusted to compensate for wear. [13]



1. Rotor.
3. Wear plate.
2. Hammers.
4. Grille.

Fig III. 3: Double-rotor hammer crusher.

III.1.2 Limestone

The extracted raw material is first coarsely crushed using an N 02 crusher. Once crushed, the crushed material is conveyed by a conveyor belt to the storage halls**.**

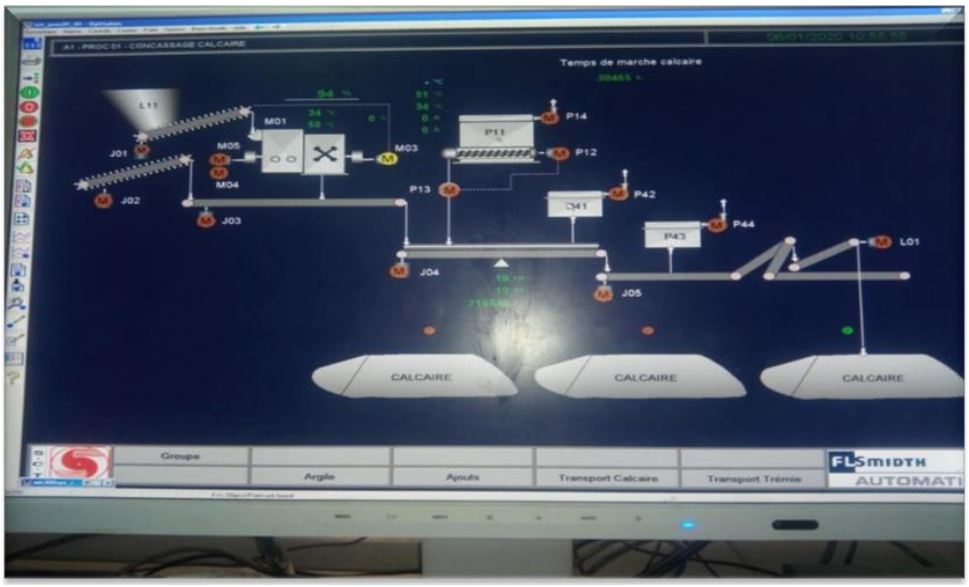


Diagram III. 1: The crushing process and transport of limestone to the associated hall

III.1.3 Clay

The raw material is crushed by a N°03 crusher, then conveyed to the storage hall by a conveyor belt.



Diagram III .2: The crushing process and transport of clay to the associated hall.

III.1.4 Additions

Additions are crushed in a N°06 crusher and then conveyed to the storage hall by an underground conveyor belt.

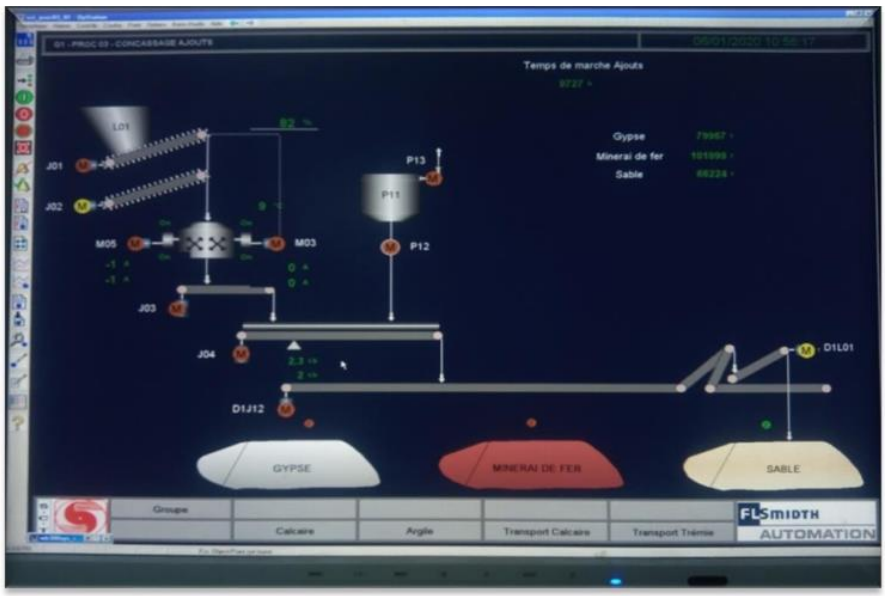


Diagram III. 3: The crushing process and transport of additives to the associated hall.

III.2 -Pre-homogenization

Table III. 2: Storage Hall.

Désignations.	Types and capacities.	Photos.
Limestone	2 piles × 14,000 t	
Limestone additions	1 pile × 5,000 t	
Clay	1 pile × 3,000 t	
Iron ore	1 pile × 3,000 t	

Gypsum	1 pile × 3,000 t	

The crushed mixture is discharged in a parallel layer using a stacker or scraper.

Material homogeneity is assessed on the basis of its most important parameter, in the case of limestone, its $CaCO_3$ content. During homogenization, variations around the mean between the material before homogenization (curve A) and after homogenization (curve B) are reduced. This reduction is known as homogenization efficiency.



Graph III. 1: Curve before and after homogenization A and B. [20]

Raw meal materials (clay, limestone, iron ore, sand) stored in the appropriate halls are conveyed by conveyor belts to the raw

meal dosing hoppers. Dosing is automatic and based on the chemical analysis of these materials.

III.3 Feeding the raw mill

Four hoppers feed the raw mills, the first for limestone, the second for sand, the third for iron ore and the last for clay.



Diagram III. 4: The raw mill feeding process.

III.4 Raw meal grinding

Raw meal grinding is carried out at the Elma Labiod cement plant at a rate of 150 t/h in a Tirax Unidan mill. This is a closed cylinder rotating around a horizontal axis.

The interior of the mill is protected by thick armor plates. These plates are not neutral, but are shaped to favor classification in the finisher compartment and percussion in the preparation compartment.

- The first compartment contains a charge of large-diameter balls.

- The second compartment contains a charge of small-diameter balls. [21]

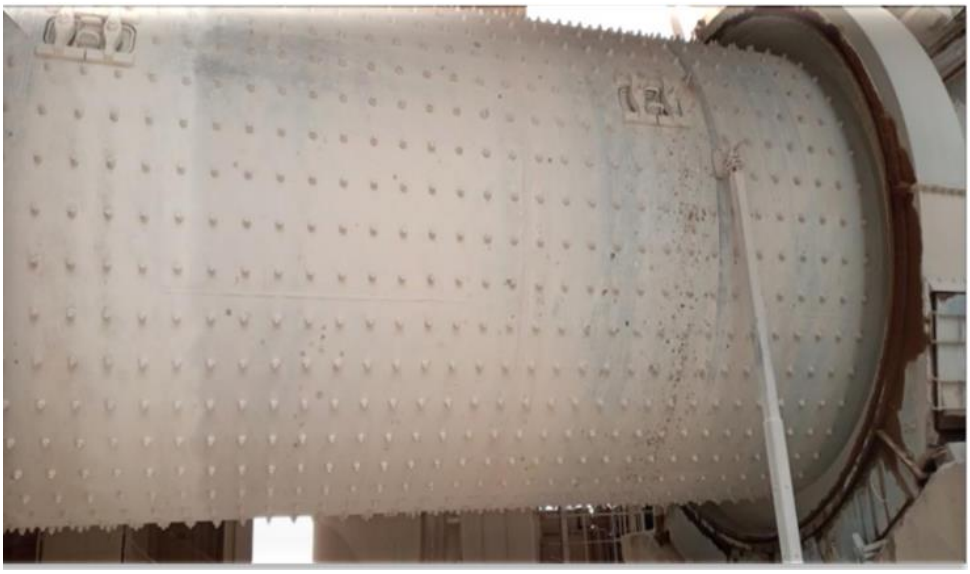


Fig III. 4: Tirax Unidan mill - Elma Labiod cement plant - TEBESSA.

The pre-homogenized raw materials must be finely ground to be chemically more reactive during firing in the kiln.

Limestone, clay, iron ore and sand, if required, are mixed together to produce raw meal in the raw milling phase, which meets the quality requirements of LSF, SM and AFM.

- For the preparation of CPJ type flour, limestone and clay are ground with the addition of 1% to 2% iron ore and 1% sand.
- Concerning the preparation of CRS type flour, the grinding of limestone and Clay with an addition of 1% to 4% iron ore and 5% sand. [15]

This flour is used to feed the kiln. According to the diagram, the raw meal leaving the mill is sent in an elevator to a separator which separates the fines from the coarse meal, the fines pass pneumatically to the storage and homogenization silos and the coarse meal returns to the mill.



Diagram III. 5: The raw milling process.

III.5 -Homogenization

The raw flour is continuously homogenized in two Claudus Peters silos, each with a capacity of 8,000 t.

The raw meal storage silos are equipped with a bubbling air system for raw meal homogenization, i.e., to standardize the flour's chemical modules.



Fig III. 5: Homogenization silos - Elma Labiod cement plant - TEBESSA –

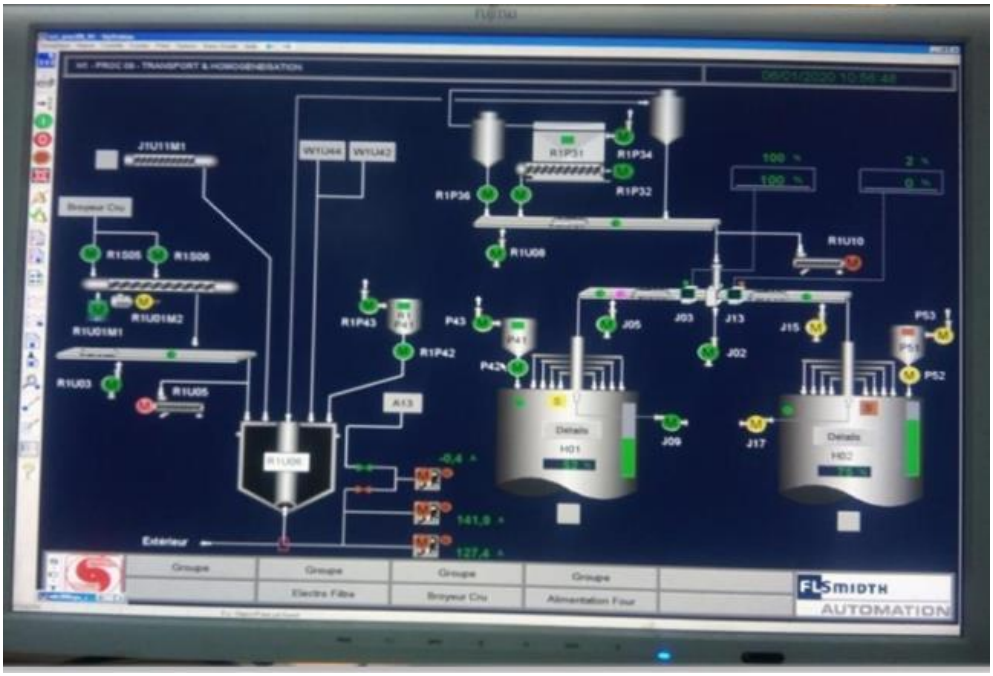


Diagram III. 6: The homogenization process.

The diagram shows the two homogenization silos. If one is out of order, the other replaces it, so as not to stop the production line.

III.6 -Dust removal

The new standards for dust emissions into the atmosphere require more efficient dust removal systems, both to protect the environment and to recycle dust from the raw mill and kiln. The dust removal system consists of eliminating dust emissions by using bag filters. [22]

These dusts are conveyed to the Schnicks hoppers or to the homogenization silos in order to refeed the kiln and increase production.

III.7 Preheating

The preheating tower is a simple 4-stage exchanger that feeds the kiln, ensuring optimal preheating of the raw meal before it passes into the kiln. The gases heat the raw powder, which circulates in the cyclones in the opposite direction by gravity; the powder thus heats up to around 800°C and thus loses its carbon dioxide (decarbonated): i.e., transformed into calcined lime. [23]

$$CaCO_3 \Rightarrow CaO + CO_2$$

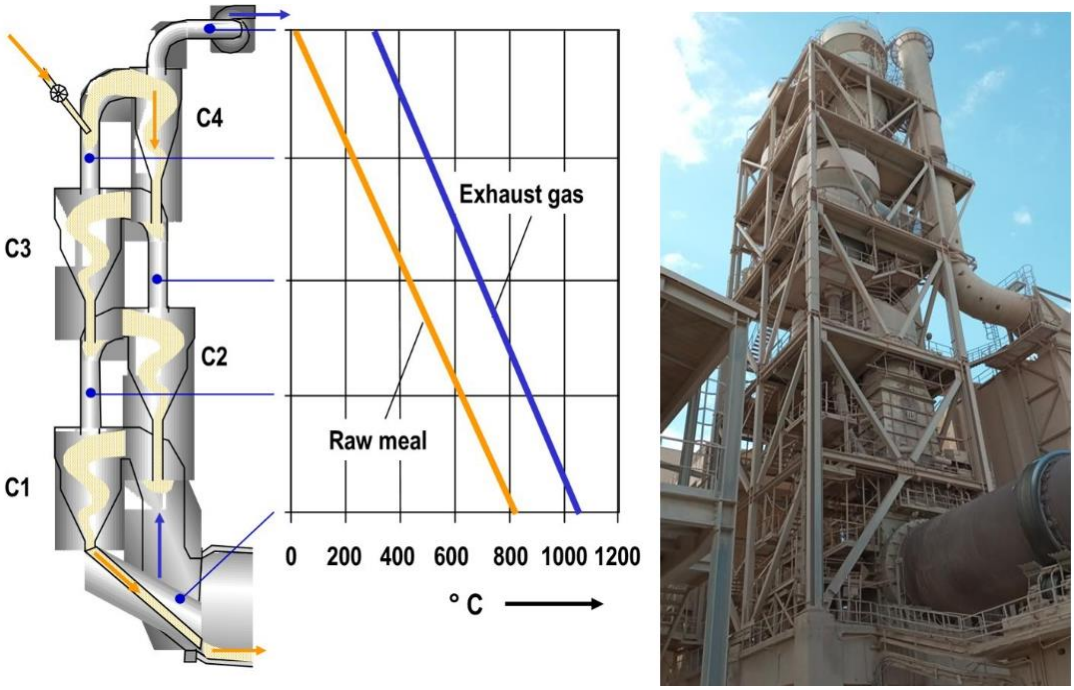


Fig III. 6: Preheating operation.

III.8 Furnace feed

The kiln is fed by the material stored (raw meal) in the two storage silos through the following circuit: extractors, elevators, schenck hopper, air slides and air lift. The diagram shows the kiln feed circuit.

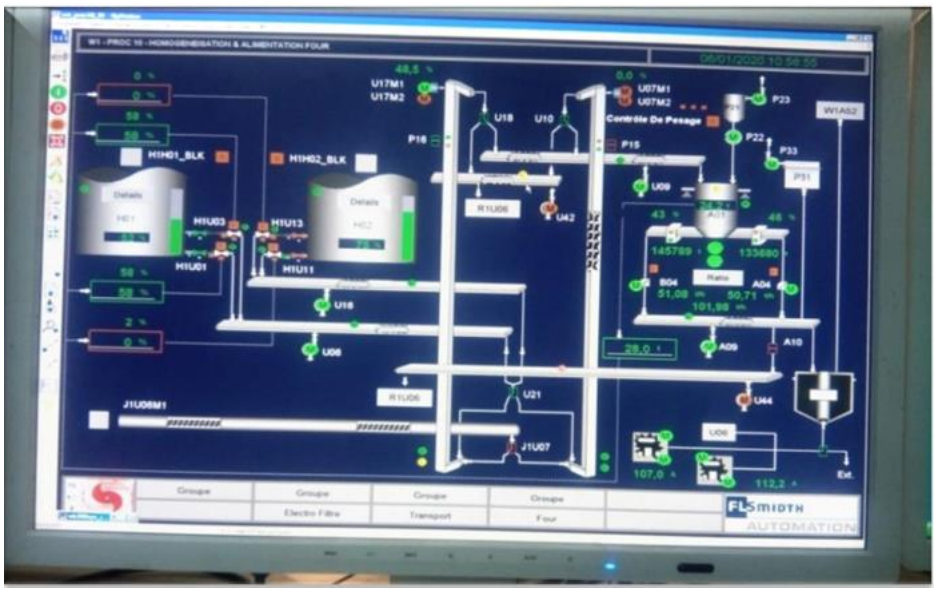


Diagram III. 7: Furnace feeding.

III.9 Furnace

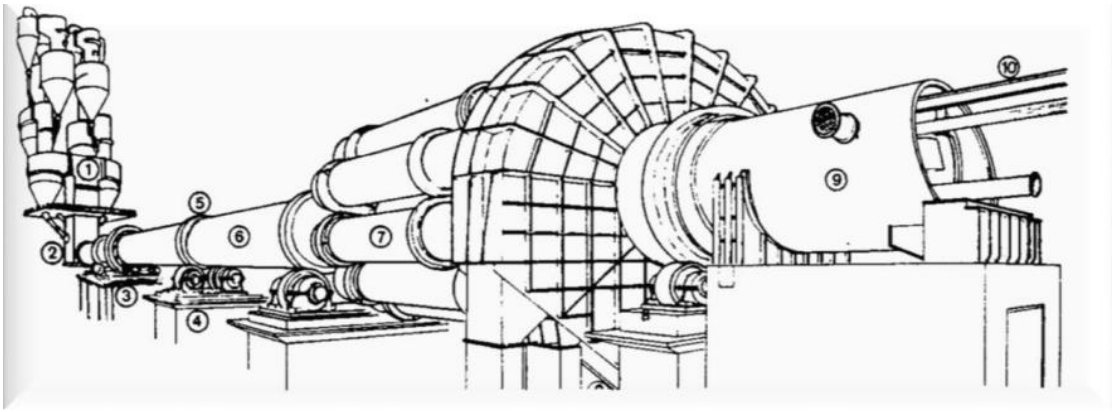
This is an energy-intensive operation. The rotary kiln is the central element of all modern clinker production plants. At the Elma Labiod cement plant, the kiln is a UNAX-type rotating steel cylinder, 68 m long and 4.5 m in diameter, inclined at an angle of 3 to 5 degrees to the horizontal, enabling the material to pass through it in 20 to 30 minutes. It is braced at intervals by roller-bearing surfaces. Rotation is transmitted to it via a ring gear, a pinion and a speed reducer.

Since it is inclined, the furnace will tend to move downstream as it rotates. This axial travel is braked by retaining rollers, installed in the immediate vicinity of one or both tires, resting on their lower flanks.

The furnace is protected against very high operating temperatures by a refractory brick lining masoned on the inside along its entire length.

The lining is sensitive to elastic deformation of the furnace and temperature variations. The furnace must operate continuously. After a stoppage, it must be fired slowly, with a uniform increase in temperature and a regular turnaround.

The downstream end of the furnace, the outlet, is closed by a bottom through which a tuyere passes. Firing temperature is around 1450°C. The furnace is fired either with oil, gas or pulverized coal, or a combination of the three. The raw materials are fed in at the kiln inlet, and move through the kiln against the flow of hot gases, until they emerge from the cooler as fired clinker.



1. 4-storey cyclone tower.
2. Oven inlet.
3. Control station.
4. Roller conveyor.
5. Tyres.
6. Furnace tube.
7. UNAX cooling system (planetary cooler).
8. Cooler outlet.
9. Tunnel.
10. Nozzle suspension.

Figure III. 7: Modern four-stage cyclone furnace. [16]



Fig III. 8: The rotary kiln - Elma Labiod cement plant - TEBESSA -.

During clinker firing, it is essential to maintain the kiln charge temperature at between 1400 and 1500°C, and the gas

temperature at around 2000°C. Energy consumption is between 3200 and 4200 kJ per ton of clinker. Clinker must also be fired in an oxidizing environment, which is why excess air is required in the clinkering zone of a cement kiln.

Clinker takes the form of dark-gray, rounded grains of irregular dimensions.



Diagram III. 8: Clinkerization (the furnace).

III.10 Cooler

The role of the UNAX Planetary cooler with 09 balloons is to lower the temperature of the clinker falling from the kiln at a temperature of around 1135°C to 80- 100°C.

III.11 Transporting clinker

Clinker is removed from the kiln and transported to 3 storage silos, each with a capacity of 8,000 tons, via bucket conveyors.



Fig III. 9: Clinker storage silos.

III.12 Feeding the cement mill

The cement mill is fed from three hoppers equipped with a weighing and dosing system (clinker, additives and gypsum) at rates of 75%, 20% and 5% respectively. There are three clinker storage silos, and the additive is a mixture of one of the following materials (slag, tuff and limestone).



Fig III. 10: Batching hopper (clinker, gypsum and additives).

Accurate and reliable weighing and dosing of the materials fed into the mill are crucial to maintaining good energy efficiency in the grinding plant. [22]



Diagram III. 9: Feeding the cement grinder.

III.13 Cement grinding

The final stage in the manufacturing process is the grinding of the clinker from the kiln. The cement manufactured must comply with Algerian standards.

The grindability of cement depends on the following factors:

- Clinker mineral composition
- Degree of clinker firing
- Grain size of clinker fed
- Desired grind
- Quantity and type of additive. [16]

At the Elma Labiod cement plant, cement grinding is carried out by a UNIDAN ball mill (throughput: 100 t/h) in a closed circuit, measuring 40 x 12 m, equipped with an adjustable-speed separator that separates fines from coarse; the fines are transferred to silos for storage, and the coarse material is returned to the mill.

The clinker is normally dry, and this mill has a paddle wheel at its inlet instead of a drying compartment, and there is no hot air draught. [16]

III.14 Cement storage silos

The cement produced by the mill is transported to 3 hermetically sealed storage silos, each with a capacity of 8,000 t. Storage of the product in the silos enables cement to be shipped regularly in the event of the workshops being shut down for maintenance. [22]

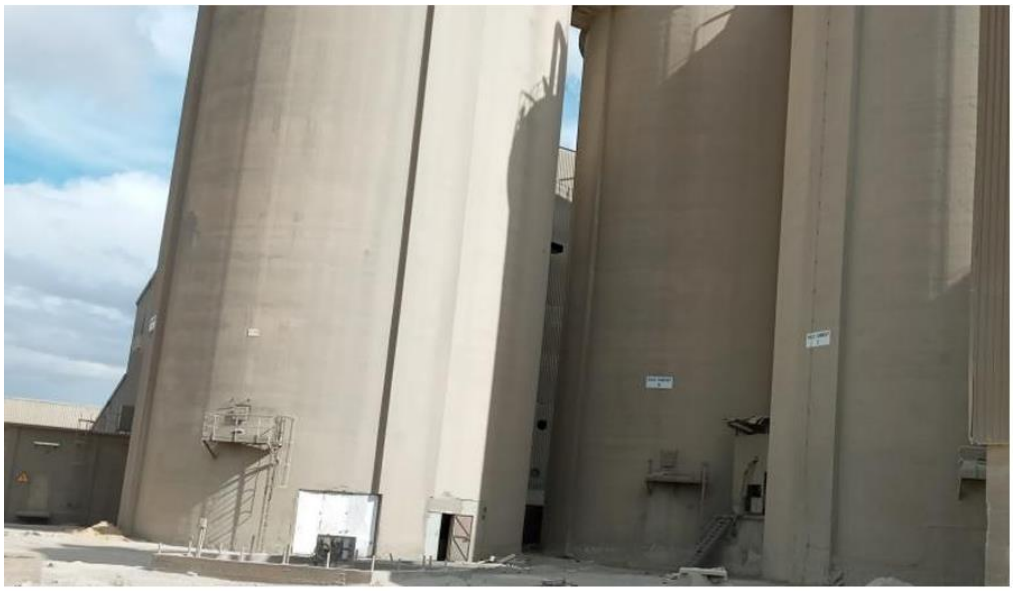


Fig III. 11: Cement storage silos - Elma Labiod cement plant - TEBESSA -.

III.15 Shipping cement in bulk and bags

Cement is shipped in two ways, either loaded directly through a bulk mouth; 250 t/h in bulk transported in trucks, special tankers, railway tippers or boats. The tanker trucks drive directly under the silo, and the cement is filled from the bottom of the silo. Extraction is by hose connected to the bottom of the silo.

Or the cement is loaded into 50 kg bags by the Flux RU bagging machine, which consists of a vertical rotating tank with 12

separate weighing systems and filling nozzles mounted on the outside of the tank, and rotating with it.

The bagger is operated by a single operator, who hooks the empty bags onto the filling spouts as soon as they pass in front of him. Immediately after hooking, the spout valve opens automatically, and when the bag is almost full, the machine stops for a moment to allow de-aeration, after which filling resumes. When the bag is full, it is immediately unhooked from the spout before it reaches the operator, and the spout is ready to receive the next bag once it has returned to its starting position. [16]



Fig III. 12: The bagging machine.

The diagram below shows how cement is shipped.



Diagram III. 10: Shipping cement in bulk.



Fig III. 13: Shipping cement by bag



Fig III. 14: A bag of cement.

Chapter IV

Chapter IV : Materials & Methods

IV.1 -Raw material laboratory

Procedure:

For the raw material analysis mode, the following steps must be followed:

- Open the inspection door at the dosing unit.
- Take a sample (10kg) twice.
- Quarter the sample using a divider, until 2kg is obtained.
- Analyze each material according to XRF instructions.

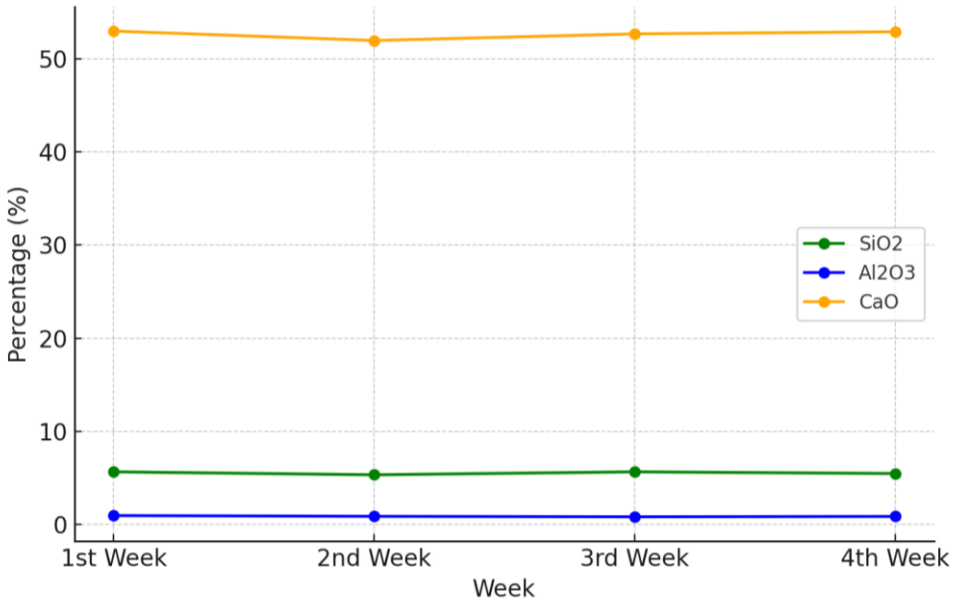
IV.1.1 Limestone pellet X-ray analysis:

This table is showing Limestone pellet analysis results for the month of February.

Table IV. 1: Limestone pellet analysis results for the month of February.

	$SiO_2(\%)$	$Al_2O_3(\%)$	$CaO(\%)$
1st Week	5.64	0.94	52.99
2nd Week	5.32	0.86	51.98
3rd Week	5.64	0.81	52.69
4th Week	5.46	0.85	52.92

This Graph IV. 1 is the curve of Limestone pellet analysis results for the month of February.



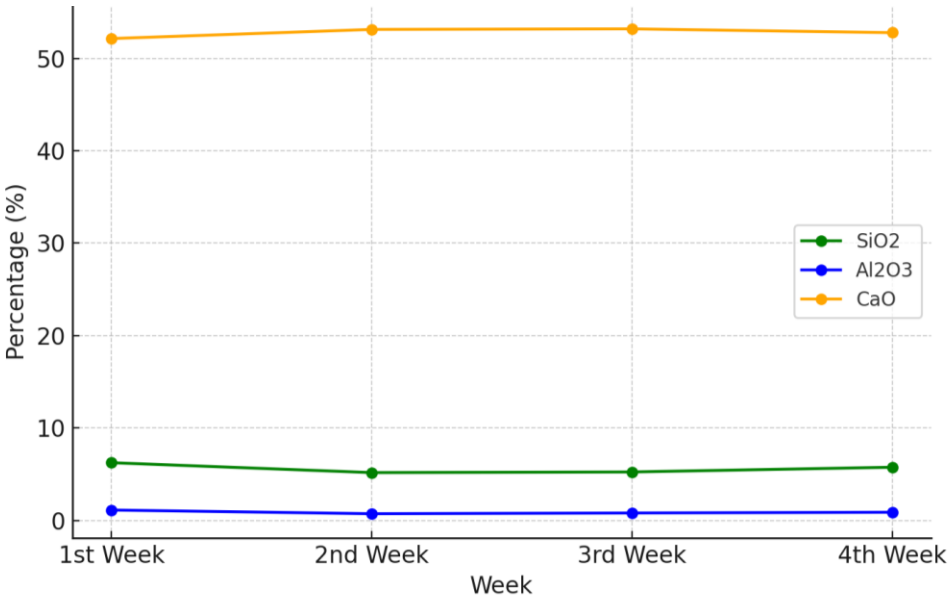
Graph IV. 1: Limestone pellet analysis results for the month of February.

This table is showing Limestone pellet analysis results for the month of march.

Table IV. 2: Limestone pellet analysis results for the month of March.

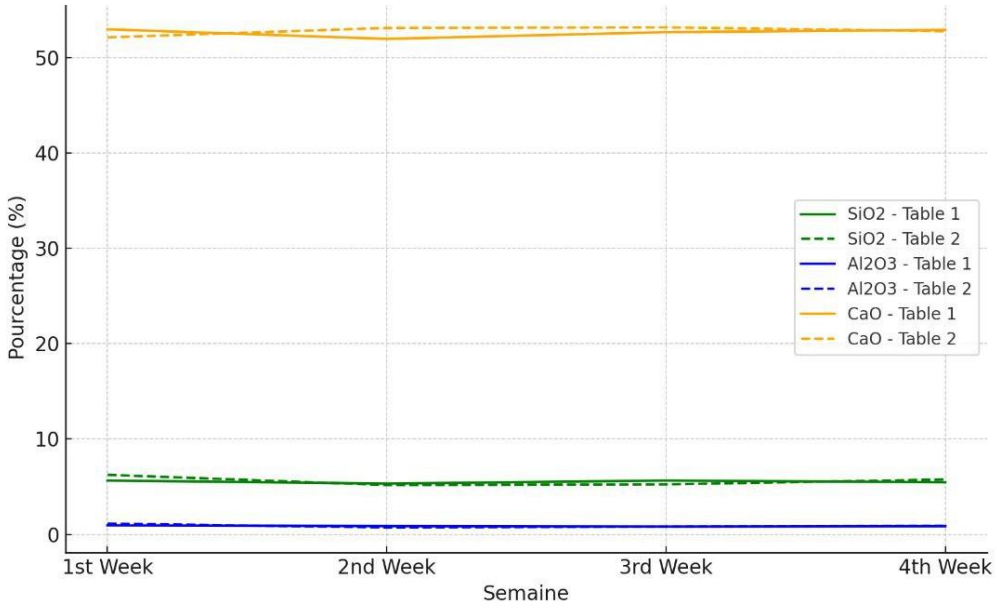
	$SiO_2(\%)$	$Al_2O_3(\%)$	$CaO(\%)$
1st Week	6.24	1.12	52.14
2nd Week	5.17	0.72	53.13
3rd Week	5.24	0.8	53.19
4th Week	5.75	0.88	52.78

This Graph IV. 2 is the curve of Limestone pellet analysis results for the month of March.



Graph IV. 2: Limestone pellet analysis results for the month of March.

This Graph IV. 3 is Curve showing the comparison of limestone content in February and March.

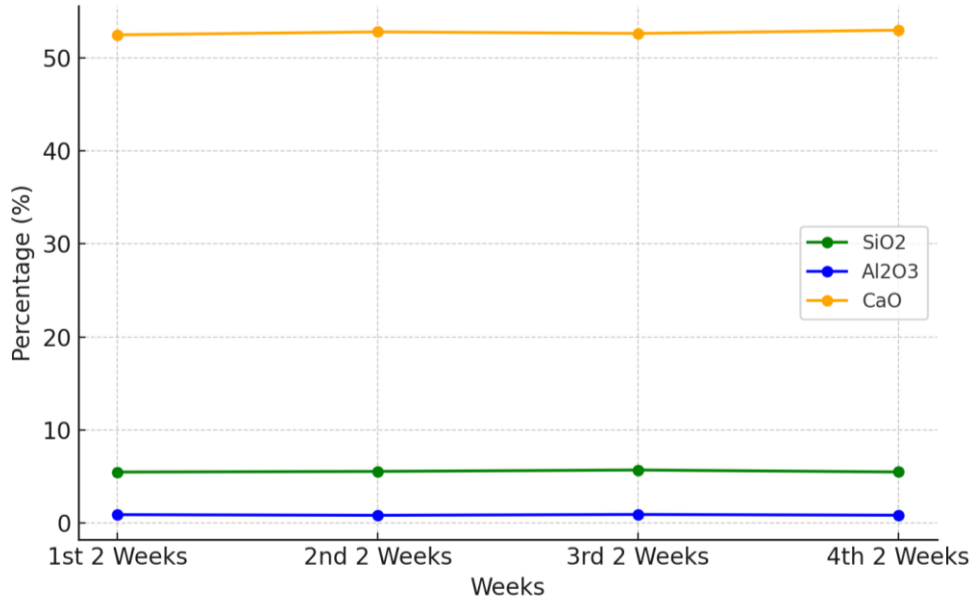


Graph IV. 3: Curve showing the comparison of limestone content in February and March.

This Table IV. 3 and Graph IV. 4 are showing Limestone pellet analysis results in two months.

Table IV. 3: Limestone pellet analysis results in two months.

	$SiO_2(\%)$	$Al_2O_3(\%)$	$CaO(\%)$
1st fortnight	5.48	0.9	52.48
2nd fortnight	5.55	0.83	52.80
3rd fortnight	5.70	0.92	52.63
4th fortnight	5.49	0.84	52.98



Graph IV. 4: Limestone pellet analysis results in two months.

Comment:

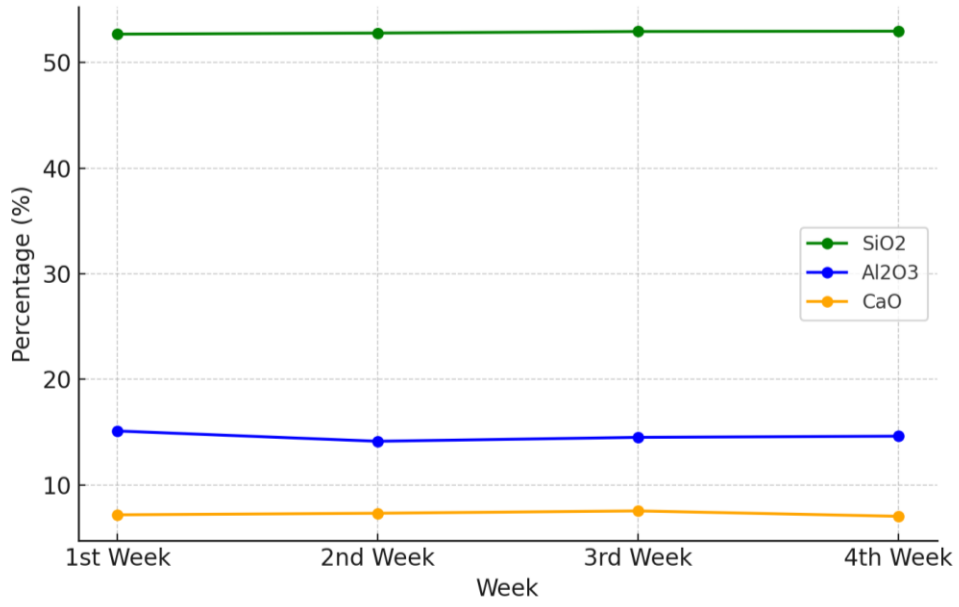
- The percentage of CaO is high (CaO>45%), the main constituent of limestone.

IV.1.2 Clay pellet X-ray analysis:

Table IV. 4 and Graph IV. 5 are showing Clay pellet analysis results for the month of February.

Table IV. 4: Clay pellet analysis results for the month of February.

	$SiO_2(\%)$	$Al_2O_3(\%)$	$CaO(\%)$
1st week	52.7	15.10	7.16
2nd week	52.8	14.13	7.31
3rd week	52.95	14.5	7.53
4th week	52.98	14.61	7.02

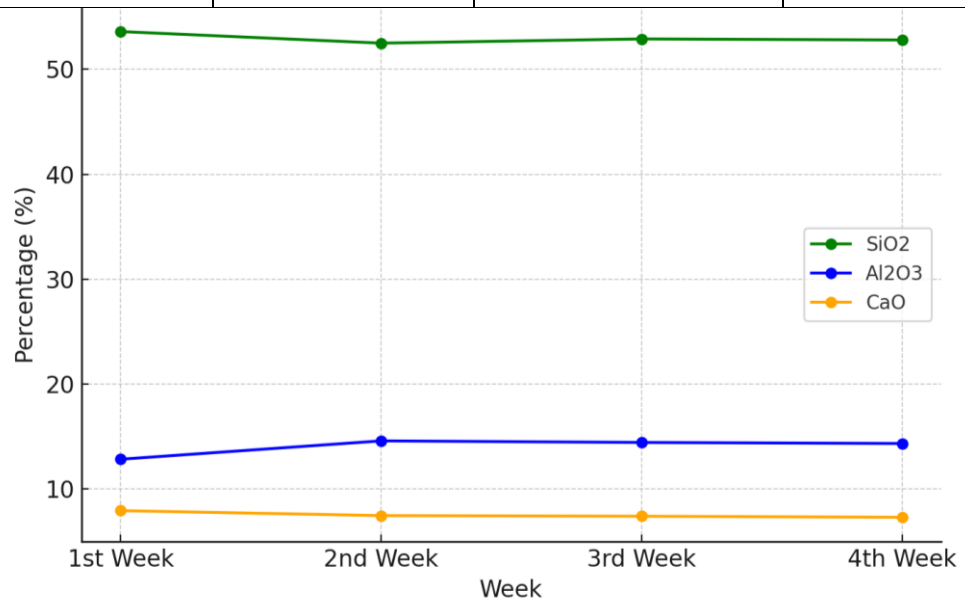


Graph IV. 5: Clay pellet analysis results for the month of February.

Table IV. 05 and Graph IV. 6 are showing Clay pellet analysis results for the month of March.

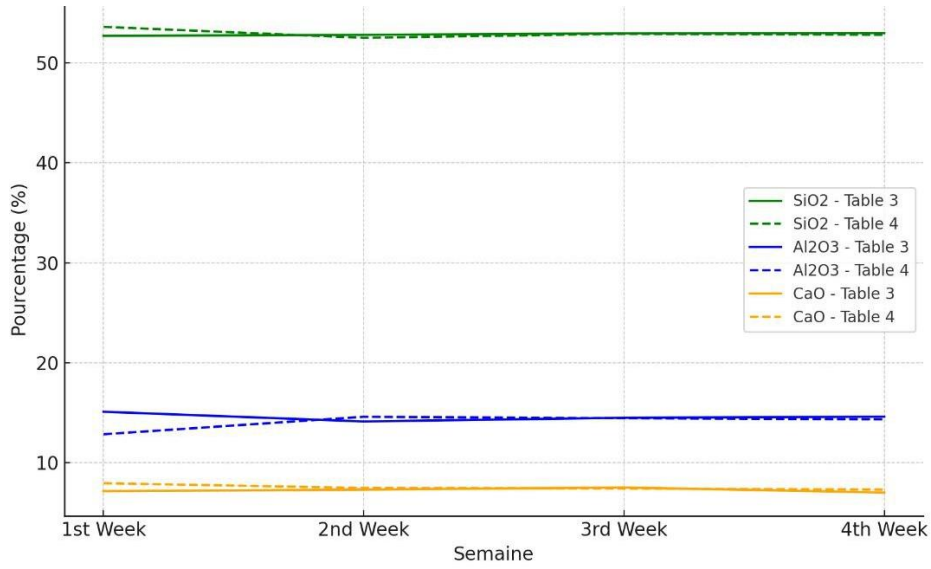
Table IV. 5: Clay pellet analysis results for the month of March.

	$SiO_2(\%)$	$Al_2O_3(\%)$	$CaO(\%)$
1st week	53.6	12.85	7.95
2nd week	52.5	14.6	7.48
3rd week	52.9	14.45	7.42
4th week	52.8	14.35	7.32



Graph IV. 6: Clay pellet analysis results for the month of March.

This Graph IV. 7 is Curve showing the comparison of clay content in February and March.

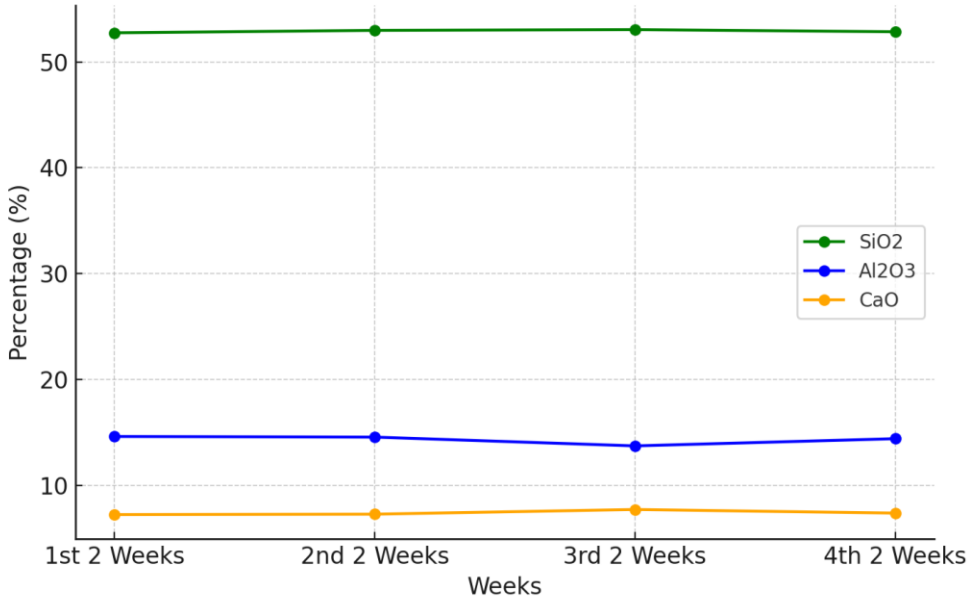


Graph IV. 7: Curve showing the comparison of clay content in February and March.

Table IV. 6 and Graph IV. 8 are showing Clay pellet analysis results in two months.

Table IV. 6: Clay pellet analysis results in two months.

	$SiO_2(\%)$	$Al_2O_3(\%)$	$CaO(\%)$
1st fortnight	52.75	14.61	7.23
2nd fortnight	52.98	14.55	7.27
3rd fortnight	53.05	13.72	7.71
4th fortnight	52.85	14.4	7.37



Graph IV. 8: Clay pellet analysis results in two months.

Comment:

- The percentage of SiO_2 and Al_2O_3 is appropriate to the standard (SiO_2 >45% and Al_2O_3>12%), these are the important elements among the clay constituents.

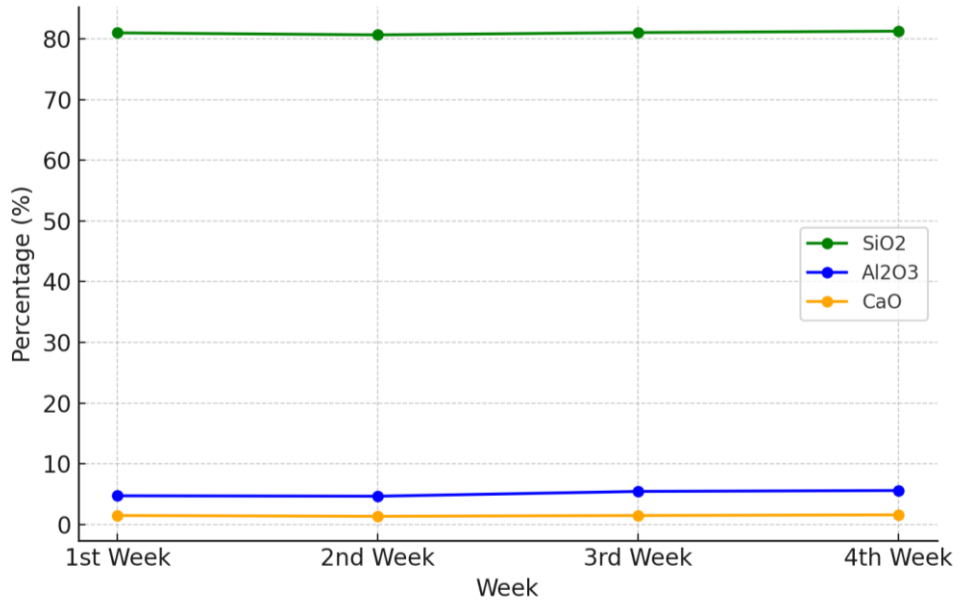
IV.1.3 Sand pellet X-ray analysis:

Table IV. 7 and Graph IV. 9 are showing sand pellet analysis results for the month of February.

Table IV. 7: Sand pellet analysis results for the month of February.

	$SiO_2(\%)$	$Al_2O_3(\%)$	$CaO(\%)$
1st week	80.99	4.71	1.46
2nd week	80.66	4.64	1.33
3rd week	81.04	5.43	1.46

4th week	81.27	5.58	1.57

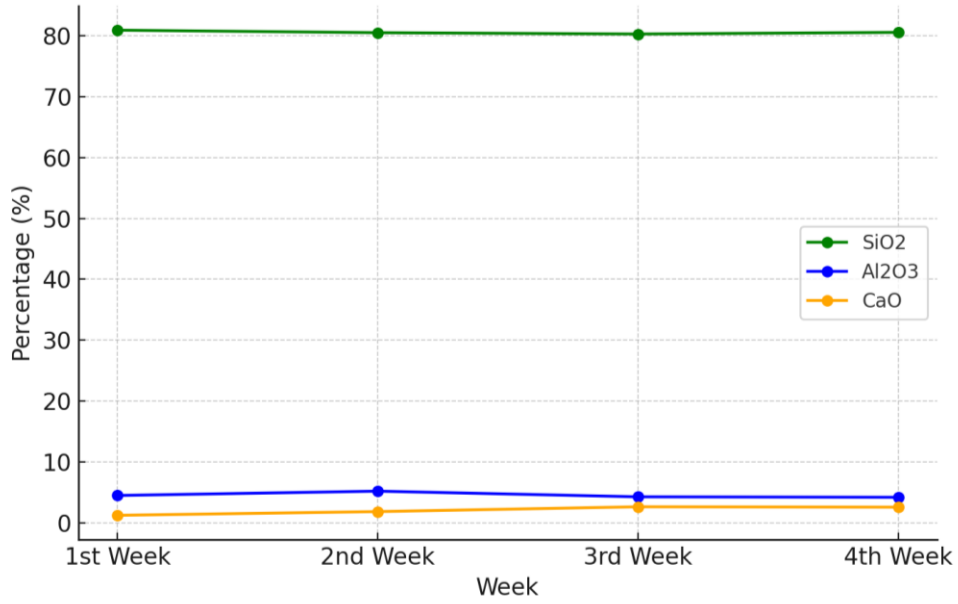


Graph IV. 9: Sand pellet analysis results for the month of February.

Table IV. 8 and Graph IV. 10 are showing sand pellet analysis results for the month of March.

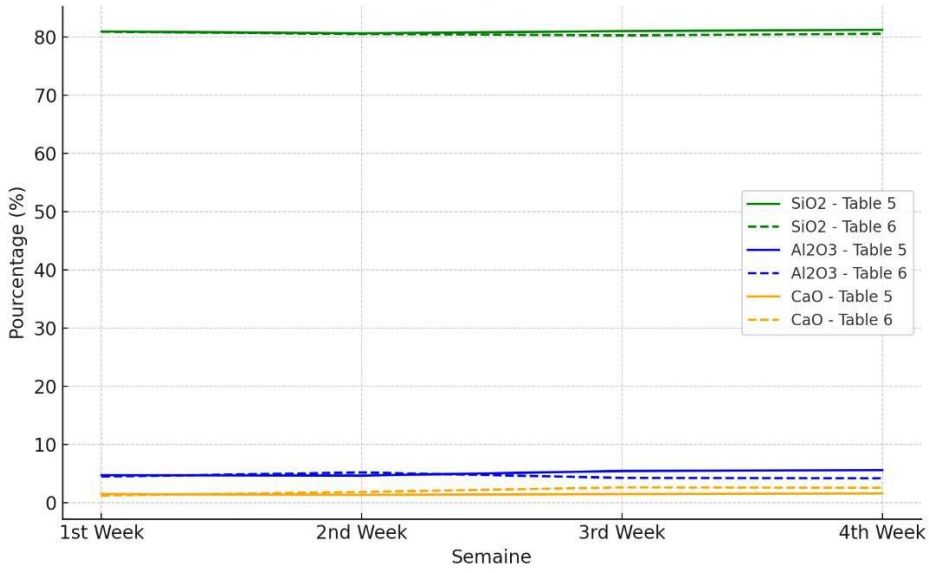
Table IV. 8: Sand pellet analysis results for the month of March.

	$SiO_2(\%)$	$Al_2O_3(\%)$	$CaO(\%)$
1st week	80.94	4.47	1.21
2nd week	80.53	5.18	1.82
3rd week	80.31	4.25	2.61
4th week	80.58	4.17	2.55



Graph IV. 10: Sand pellet analysis results for the month of March.

This Graph IV. 11 is Curve showing the comparison of sand content in February and March.

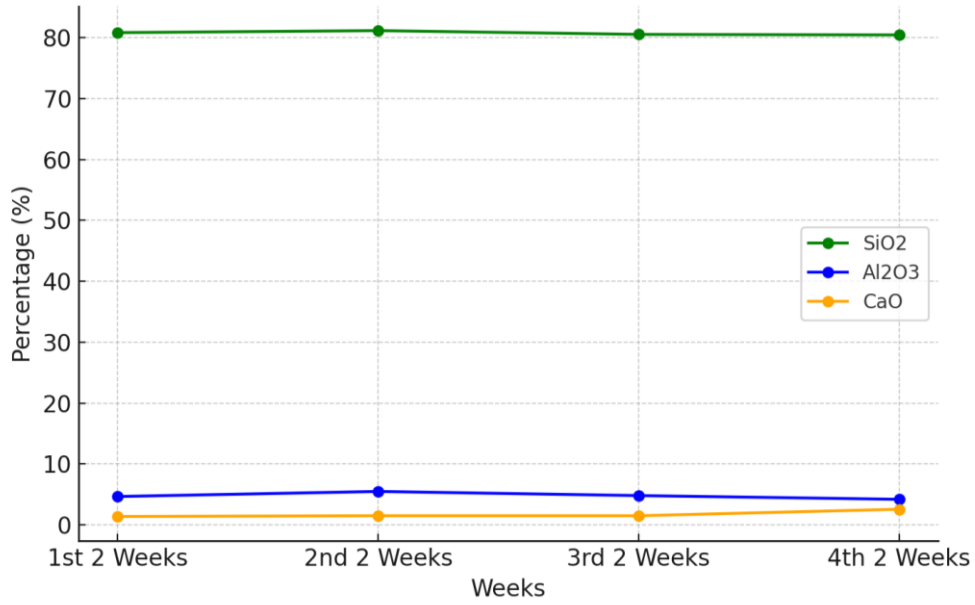


Graph IV. 11: Curve showing the comparison of sand content in February and March.

Table IV. 9 and Graph IV. 10 are showing sand pellet analysis results in two months.

Table IV. 12: Sand pellet analysis results in two months.

	$SiO_2(\%)$	$Al_2O_3(\%)$	$CaO(\%)$
1st fortnight	80.82	4.67	1.39
2nd fortnight	81.15	5.50	1.51
3rd fortnight	80.53	4.82	1.51
4th fortnight	80.44	4.21	2.58



Graph IV. 12: Sand pellet analysis results in two months.

Comment:

- The percentage of SiO_2 is high (SiO_2>45%), the main constituent of sand.

IV.2 Production laboratory:

Various methods of analysis are used:

IV.2.1 ray analysis:

This is a method of analysis designed to determine the quantity of the elements making up a given sample very quickly and with considerable precision, in order to ascertain its quality.

XQC: is an X-ray quality control system that detects the following nine elements: $CaCO_3$, SiO2, Al2O3, MgO, K2O, Fe2O3, Na2O, SO3 and Cl, and the results are displayed on a computer controlled by special software.

These results are used to correct the dosing setpoints, which are automatically corrected by the control room, and to monitor product conformity throughout the process.

IV.2.2 Preparation of the furnace feed pellet for X-ray analysis in accordance with XQC instruction:

Sampling is carried out at the silo outlet by hovercraft.

Equipment used:

Oven feeder, pelletizer, X-ray.

Procedure:

To prepare a furnace feed pellet.

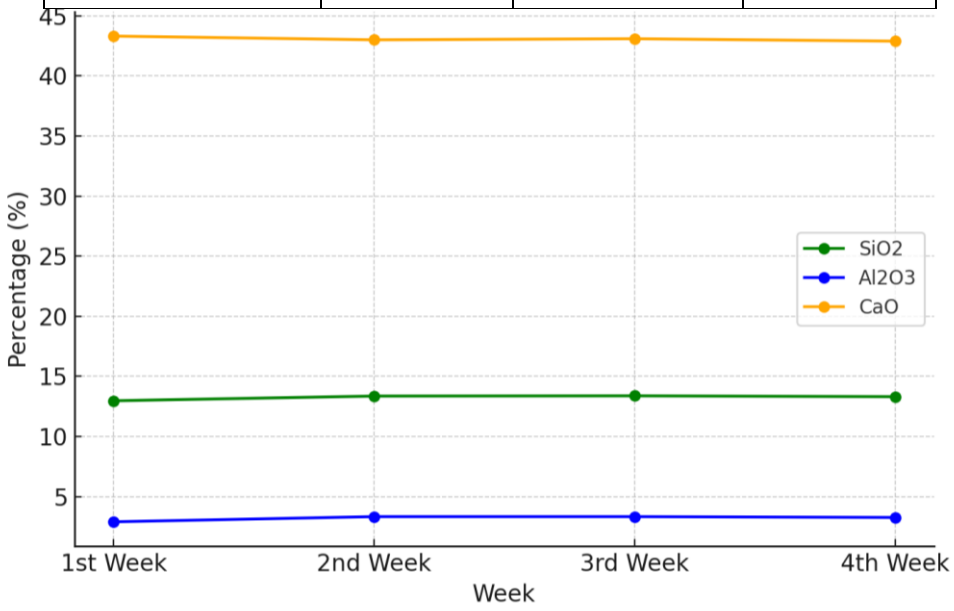
- Weigh 7g of oven feed into the pelletizer.
- Analyze the pellet by X-ray.

- Record the results displayed by the XQC in a register.

based on X-ray analysis.

Table IV. 10: Furnace feed pellet analysis results in February.

	$SiO_2(\%)$	$Al_2O_3(\%)$	$CaO(\%)$
1st week	12.97	2.90	43.31
2nd week	13.36	3.33	43
3rd week	13.38	3.33	43.09
4th week	13.31	3.26	42.89

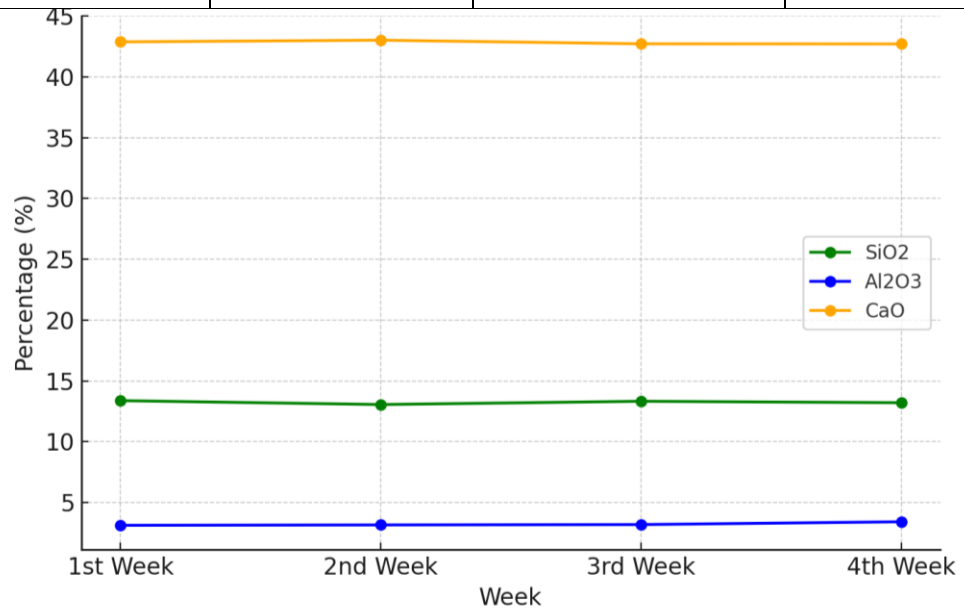


Graph IV. 13: Furnace feed pellet analysis results in February.

Table IV. 11: Furnace feed pellet analysis results in March.

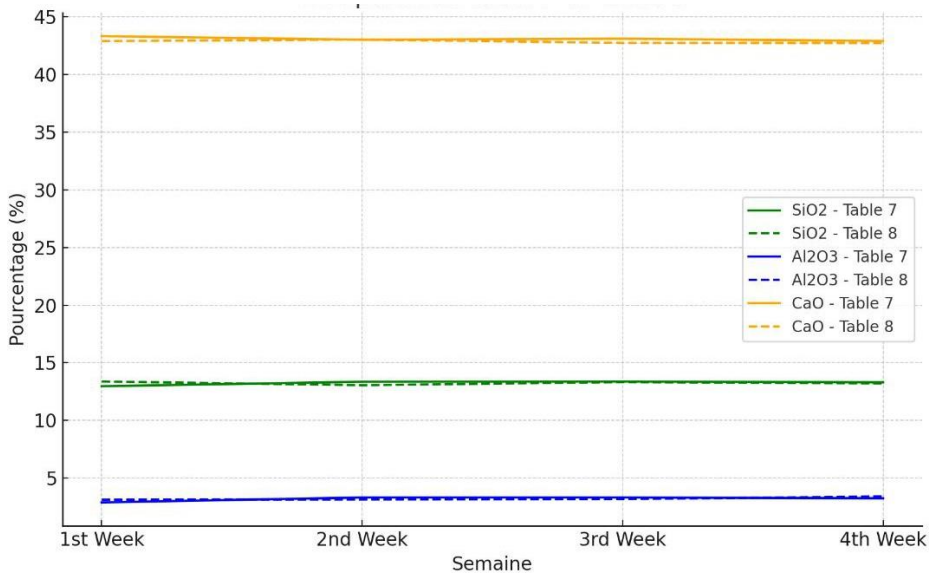
	$SiO_2(\%)$	$Al_2O_3(\%)$	$CaO(\%)$
1st week	13.38	3.13	42.88
2nd week	13.06	3.16	43.02
3rd week	13.33	3.19	42.72

4th week	13.21	3.42	42.71



Graph IV. 14: Furnace feed pellet analysis results in March.

This Graph IV. 15 is Curve showing the comparison of furnace feed content in February and March.

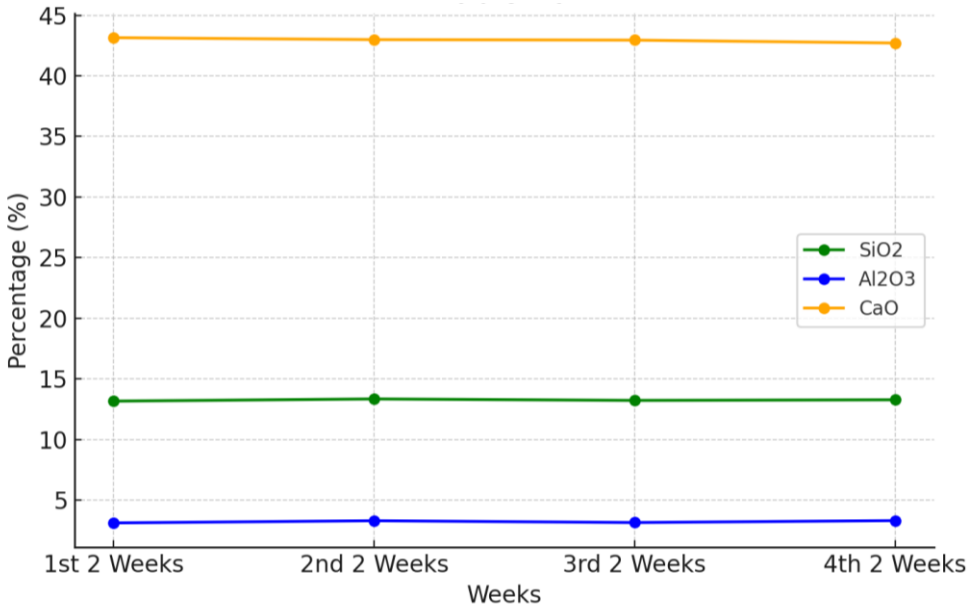


Graph IV-15: Curve showing the comparison of furnace feed content in February and March.

Table IV. 12 and Graph IV. 16 are showing Furnace feed pellet analysis results in two months.

Table IV-12: Furnace feed pellet analysis results in two months.

	$SiO_2(\%)$	$Al_2O_3(\%)$	$CaO(\%)$
1st fortnight	13.16	3.11	43.15
2nd fortnight	13.34	3.29	42.99
3rd fortnight	13.22	3.14	42.95
4th fortnight	13.27	3.30	42.71



Graph IV. 16: Furnace feed pellet analysis results in two months.

IV.2.3 Preparation of clinker pellets for X-ray analysis according to XQC instructions :

Materials used:

Glass bottle, Wax, Ground clinker, Grinder, Electronic balance, Pelletizer, X-ray.



Fig IV. 1: Pelletizer.



Fig IV. 2: X-ray.

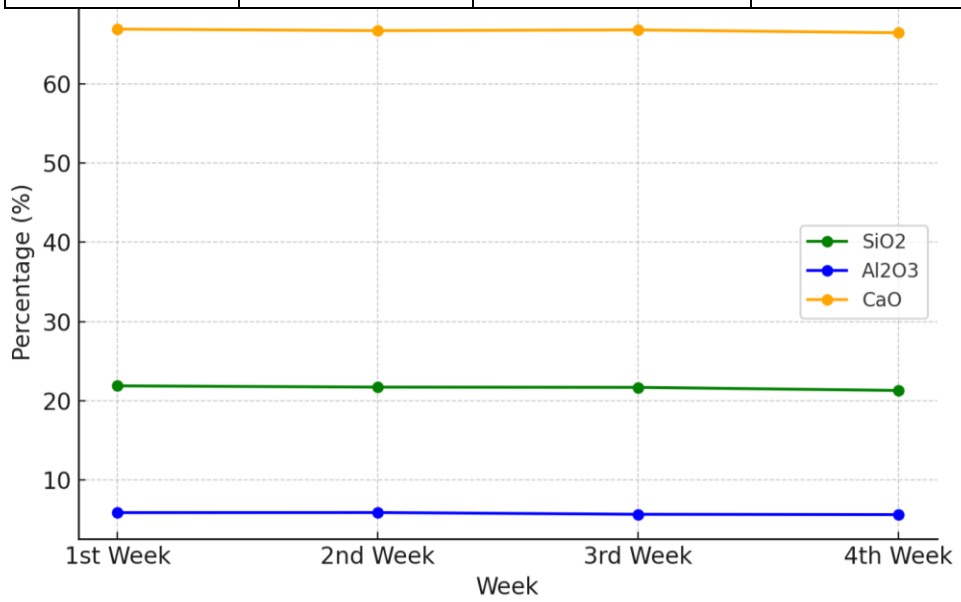
Procedure:

To prepare a clinker pellet:

- Grind a clinker sample.
- Weigh 7g of ground clinker.
- Add 1g of wax and place the mixture in a glass bottle.
- Place the mixture in the pelletizer to prepare a pellet.
- Analyze with XQC and display percentages of all clinker constituents.
- Record results in the logbook.

Table IV. 13: Clinker pellet analysis results for the month of February.

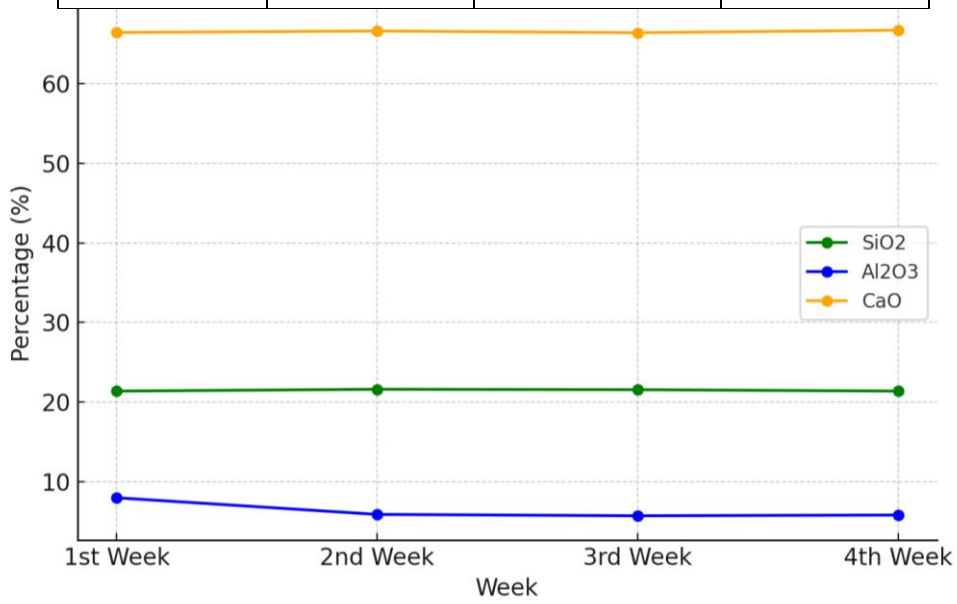
	$SiO_2(\%)$	$Al_2O_3(\%)$	$CaO(\%)$
1st week	21.90	5.92	66.87
2nd week	21.74	5.93	66.68
3rd week	21.71	5.71	66.77
4th week	21.32	5.67	66.41



Graph IV. 17: Clinker pellet analysis results for the month of February.

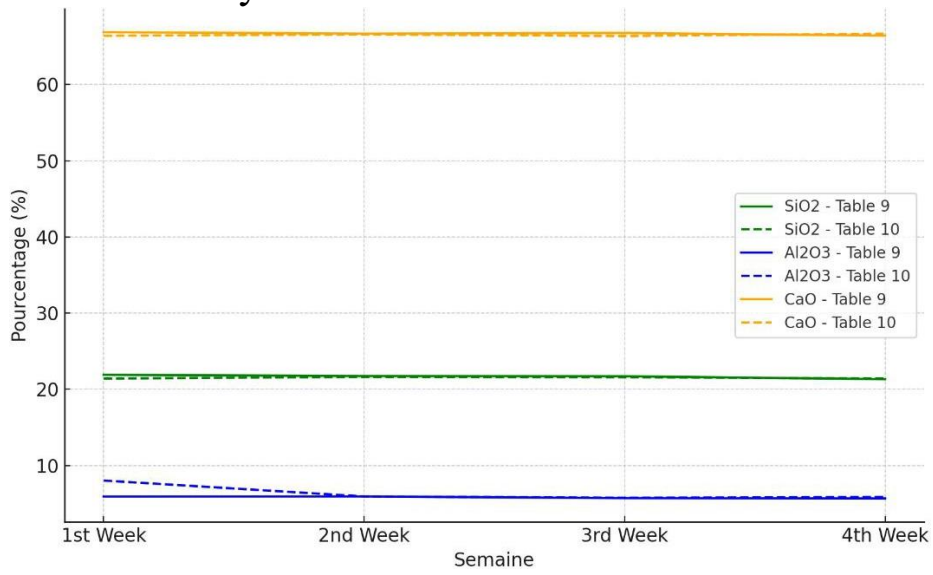
Table IV. 14: Clinker pellet analysis results for the month of March.

	$SiO_2(\%)$	$Al_2O_3(\%)$	$CaO(\%)$
1st week	21.40	8.02	66.40
2nd week	21.63	5.93	66.58
3rd week	21.58	5.76	66.37
4th week	21.40	5.85	66.68



Graph IV. 18: Clinker pellet analysis results for the month of March.

This Graph IV. 15 is Curve showing the comparison of clinker content in February and March.

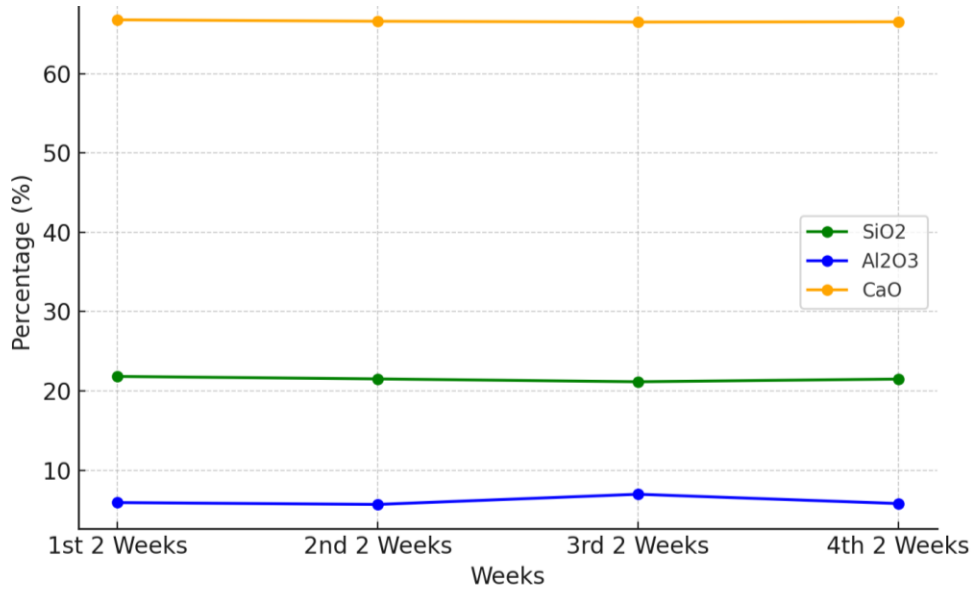


Graph IV. 19: Curve showing the comparison of clinker content in February and March.

Table IV. 15 and Graph IV. 20 are showing clinker pellet analysis results in two months.

Table IV. 15: Clinker pellet analysis results in two months.

	$SiO_2(\%)$	$Al_2O_3(\%)$	$CaO(\%)$
1st fortnight	21.82	5.92	66.77
2nd fortnight	21.51	5.69	66.59
3rd fortnight	21.15	6.97	66.49
4th fortnight	21.49	5.80	66.52



Graph IV. 20: Clinker pellet analysis results in two months.

Comment:

- The percentage of CaO, SiO_2 and Al_2O_3 is appropriate to the standard:

➢ CaO : 62-67%
➢ SiO_2: 20-25%
➢ Al_2O_3 : 4-8%

IV.2.4 Preparation of the cement pellet for X-ray analysis according to XQC instructions:

To prepare a cement pellet:

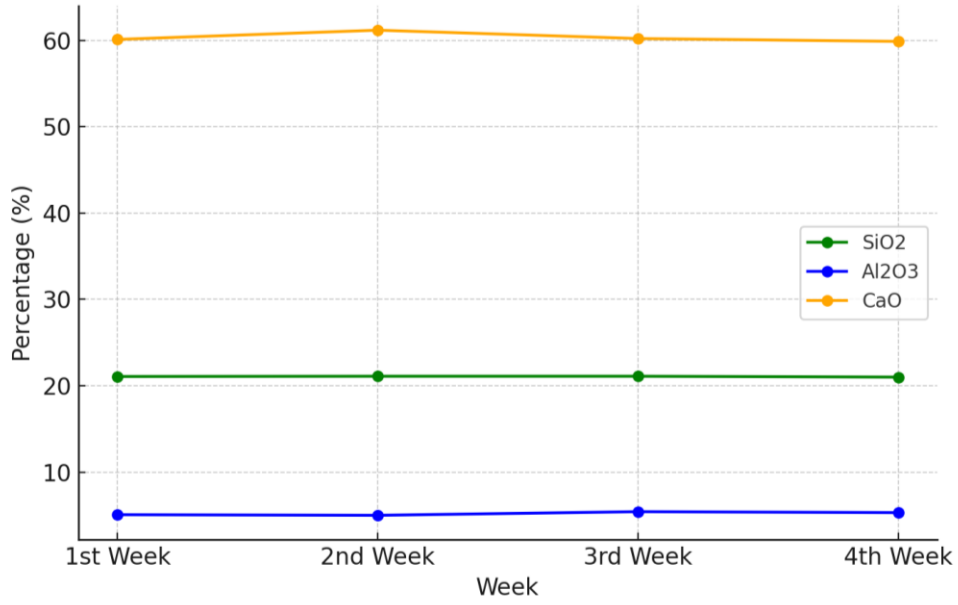
- Weigh 7g of cement.
- Add 1g of wax and place the mixture in a glass bottle.
- Place the mixture in the pelletizer to prepare a pellet.
- Analyze with XQC.
- Display percentages of all cement constituents.
- Record results in register.

- If $C_3A < 5$ → CRS cement type.
- If C_3A (5:9) → the cement type is CPJ.

- Communicate result to control room.

Table IV. 16: Cement pellet analysis results for the month of February.

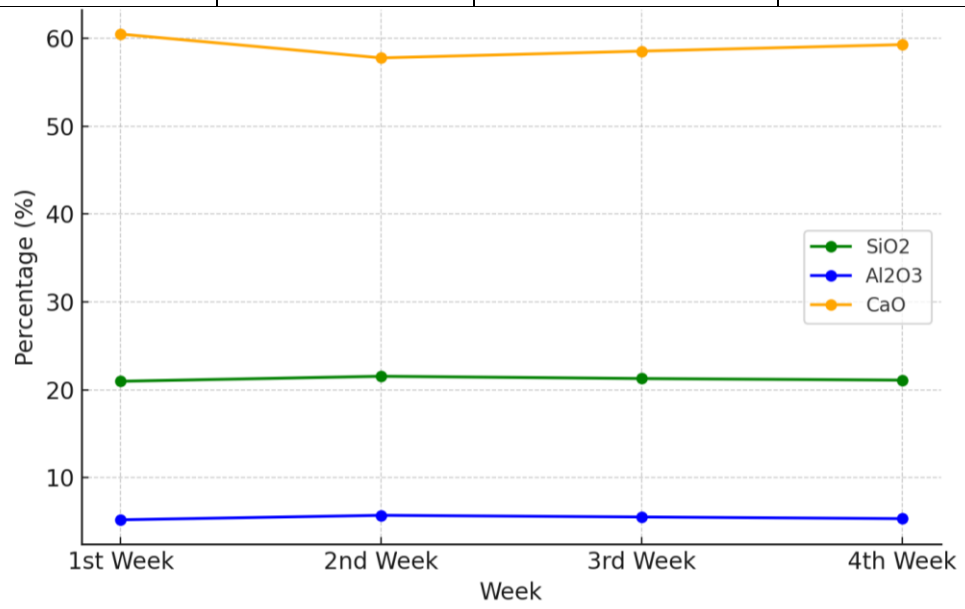
	$SiO_2(\%)$	$Al_2O_3(\%)$	$CaO(\%)$
1st week	21.07	5.06	60.12
2nd week	21.10	4.99	61.19
3rd week	21.1	5.41	60.22
4th week	21	5.30	59.89



Graph IV. 21: Cement pellet analysis results for the month of February.

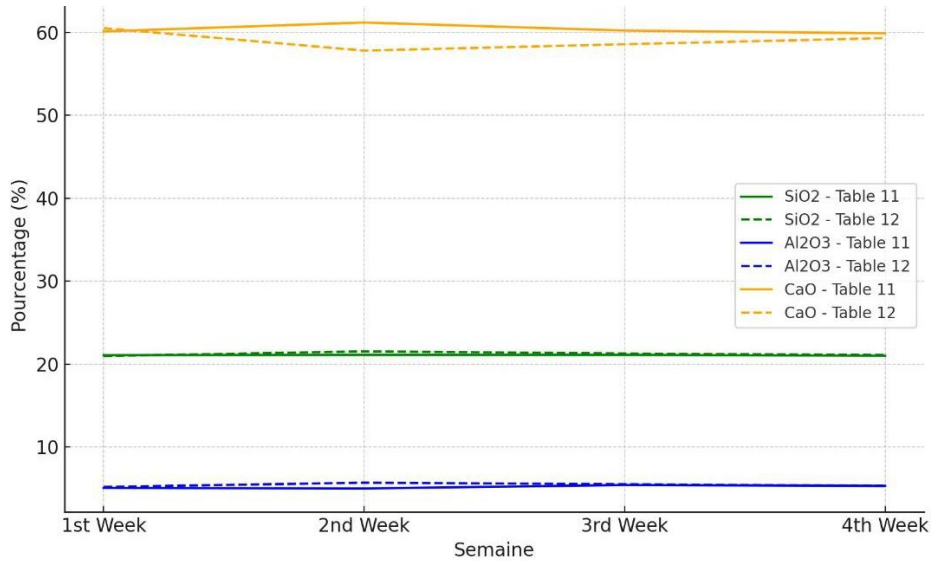
Table IV. 17: Cement pellet analysis results for the month of March.

	$SiO_2(\%)$	$Al_2O_3(\%)$	$CaO(\%)$
1st week	20.96	5.18	60.51
2nd week	21.53	5.69	57.80
3rd week	21.27	5.50	58.57
4th week	21.09	5.31	59.31



Graph IV. 22: Cement pellet analysis results for the month of March.

This Graph IV. 23 is Curve showing the comparison of clinker content in February and March.

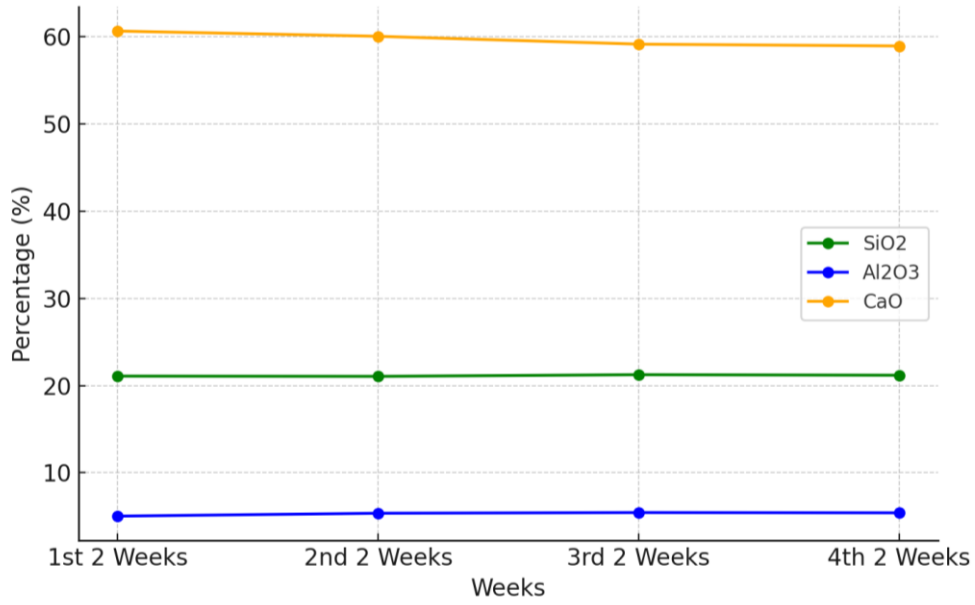


Graph IV. 23: Curve showing the comparison of cement content in February and March.

Table IV. 18 and Graph IV. 24 are showing clinker pellet analysis results in two months.

Table IV. 18: Cement pellet analysis results in two months.

	$SiO_2(\%)$	$Al_2O_3(\%)$	$CaO(\%)$
1st fortnight	21.08	5.02	60.65
2nd fortnight	21.05	5.35	60.05
3rd fortnight	21.24	5.43	59.15
4th fortnight	21.18	5.40	58.94



Graph IV. 24: Cement pellet analysis results in two months.

Table IV. 22: Cement quality standards analysis

	$SiO_2(\%)$	$Al_2O_3(\%)$	$CaO(\%)$	$SO_3(\%)$	C_3A
1st fortnight	21.08	5.02	60.65	2.34	7.59
2nd fortnight	21.05	5.35	60.05	2.44	8.67
3rd fortnight	21.24	5.43	59.15	2.36	8.59
4th fortnight	21.18	5.40	58.94	2.24	8.26

Comment:

- The percentage of SO_3 and C_3A is appropriate to the standard ($SO_3 \leq$ 3,5% and C_3A 5:9), these are the important elements to define the cement quality.
- The cement is on the standards.

IV.2.5 Determination of rejects with the ALPINE device:

This device is used for very fine dry sieving, without handling the material. The ALPINE sifter operates without any mechanical movement of the sieve or other parts in contact with the material, but simply by air current.

IV.2.5.a. Procedure for determining raw meal refusal on a 90µ sieve:

Equipment used:

Raw meal, Alpine apparatus, electronic balance.



Fig IV. 3: Alpine apparatus.

Procedure:

Perform the analysis every hour.

- Weigh 5 g of raw flour (P_1).

- Sieve through a 90µ sieve for 03 minutes on the Alpine apparatus.
- Weigh the rest of the sample (P_2).
- Calculate refusal using the formula:

$$\text{Refusal} = P_2 \times 100/P_1.$$

Where:

- P_1: Raw meal weight.
- P_2: Rejection on 90µ sieve.

The results of the raw flour analysis by reject are shown in Table IV. 19.

Table IV. 19: Results of R.F refusal analysis in two months.

	Refusal 90µ
1st fortnight	12.22
2nd fortnight	12.28
3rd fortnight	12.4
4th fortnight	12.06

- Report results to the control room.

IV.2.5.b. Determination of cement refusal on 45µ sieve: (same procedure as for raw meal):

The results of cement refusal analysis are shown in Table IV. 20.

Table IV. 20: Cement refusal analysis results in two months.

	Refusal 45µ
1st fortnight	12.87
2nd fortnight	12.67
3rd fortnight	12.02
4th fortnight	11.66

8< Refusal <15 %, the head engineer corrects and eliminates the cause of the non-conformity.

Comment:

We note that the refusal of raw flour and cement is between 11 and 13%, indicating good product quality.

- Record results in the logbook.

IV.3 Titration analysis:

IV.3.1 Titration analysis of raw flour:

Equipment used:

Electronic balance, 250 ml flask, Hcl, burette, distilled water, hot plate, phenolphthalein, NaOH.

Procedure:

To determine the titration of raw flour:

- Weigh 0.5g of raw flour into a 250 ml flask.
- Add 25 ml of HCL 0.5 N using a burette.
- Add distilled water to 100 ml.
- Carry the solution with a chisel until boiling and cool the solution.
- Add 04 drops of phenolphthalein.
- Titrate with 0.25 N NaOH solution until red.
- Enter results into XQC system.
- ➢ From the results, the quantity of limestone and the quantity of clay required are determined.
- Record the results in the logbook.

IV.3.2 Free lime :

Free lime is lime not combined with the mineralogical constituents of clinker.

It causes swelling and cracking in concrete when its percentage exceeds 2.5% in a cement.

IV.3.2.a. Determination of free lime in clinker:

Materials used:

Under-water pump, beaker, funnel, CaO indicator, ethylene glycol solution, water bath.



Fig IV. 4: Water bath.

Procedure:

- Weigh 1g of well ground clinker.
- Place the sample in a flask and add 50 ml Ethylene glycol.
- Place the flask in a water bath at 65-70°C for 30 minutes.
- Aspirate the liquid through a 5 cm3 Buchner funnel with filter paper into a 250 ml vacuum filtration flask.
- Add 5 drops of CaO indicator.
- Titrate with Hcl 0.1 N until solution color changes from green to pink.
- Calculate % free CaO from titration volume according to formula:

$$\text{Free CaO} = Vt \times CST.$$

▪ Vt= volume Hcl consumed in titration.

Table IV-21 shows the percentages of uncombined lime in clinker.

Table IV-21: Test results for free lime in two months.

	Free CaO
1st fortnight	0.98
2nd fortnight	1.08
3rd fortnight	0.91
4th fortnight	0.96

- Record the results on the register.
- Communicate results to control room.

➢ If free CaO > 2.5 % => discharge to incinerator hopper.

IV.3.2.b. Determination of cement free lime:(same procedure as clinker).

General conclusion

Conclusion

This study highlighted the decisive role of raw material characterization in the cement manufacturing process. Through in-depth geological and chemical analysis at the Elma Labiod plant, the results confirm that material variability has a direct impact on the stability of the cooking process and the quality of the finished product.

The use of X-ray fluorescence and titration made it possible to accurately monitor the composition of raw materials (limestone, clay, sand) and quickly adjust dosages to maintain stable kiln feed and obtain clinker that met requirements. This approach has reduced quality deviations and non-conformity rates in the cement produced.

In conclusion, it is strongly recommended to reinforce the quality control system by:
- Recommending that Elma Labiod cement plant carry out characterization control, by plotting comparative curves over a well-defined period for the raw materials used in cement manufacture.

This measure is essential to guarantee product conformity, improve industrial performance and meet market requirements in terms of quality and durability.

Bibliographical references

Bibliographical references:

[1] Company documentation.

[2] Centre des Etudes et de services Technologiques de l'Industries des Matériaux de Construction (CETIM), 2019, « Rapport géologique actualisé du gisement de calcaire D'Elma labiod .

[3] Takoua MOUSSA. (2022). Caractérisation et valorisation des clinkers incuits

[4] https://fr.statista.com › statistiques

[5]: S. CHARAF EDDINE. (2023). Etude comparative des propriétés rhéologiques des pâtes de ciments.

[6] CEMBUREAU. (2022). Environmental *Product Declaration for Cement CEM I*.

[7] ScienceDirect. (n.d.). *Blended cement*.

[8] Thermo Fisher Scientific. (2024). *Analysis of natural pozzolan in cement*.

[9] Cement Plants. (n.d.). *White cement manufacturing process*.

[10] Conservation Technology Ireland. (2023). *Prompt cement*.

[11] Brick&Bolt. (2023). *Quick setting cement – Uses, properties and advantages*.

[12] Britannica – The Major Cements: Composition and Properties

[13] Mouna Mizeb (2020), Analyse et caractérisation des constituants du ciment cas de la cimenterie d'Elma Labiod.

[14] HEDMESSAOUD Fayssal, SAAD Farid. (2020). Influence des processus de chargement et de transport sur la productivité

d’une carrière. Cas de la carrière de : Cimenterie Elma Labiod. Tébessa

[15] ZAÏT. M, et DJAMA. Y. (Décembre 2017). L’industrie du ciment, revue du ministère de l’industrie et des mines N°00.

[16] SMIDTH. F. L. (1993). Parts & services division, brochure de la cimenterie d’El Ma LAbiodh.

[17] Société des ciments Tébessa (2024). Gisement de calcaire (El Ma Labiodh), plan annuel d’exploitation.

[18] Société des ciments Tébessa (2024). Gisement d’argile (El Ma Labiodh), plan annuel d’exploitation.

[19] Société des ciments Tébessa (2024). Gisement de sable (El Ma Labiodh), plan annuel d’exploitation.

[20] MBEGUE. S. (2006). Etude théorique des résultats comparatifs et in situ en vue de la maîtrise de la qualité. Projet de fin d’études en génie civil, université de CHEIKH ANTA DIOP DE DAKAR.

[21] ABID. K. (2014). Etude AMDEC D’un Broyeur a Boulets Type Unidan. Mémoire de master 2 en science et technologie, université d’Annaba.

[22] HELLAL W. et al. Fichier pris de laboratoire de la cimenterie d’El Ma Labiodh.

[23] DJEBAILI. F, et ENNANY. M. (2017). Développement d’une méthodologie de la maintenance par la fiabilité d’un système électromécanique. Mémoire de master 2 en mines, université de Tébessa.