Materials Research Proceedings 40 (2024) 240-247 https://doi.org/10.21741/9781644903117-26

Evaluating the Influence of Shale Extracted from the Settat Khouribga Region on the Characteristics of Concrete

Ayoub SOUILEH[1*], Latifa OUADIF[1], Driss EL HACHMI[2], Mohammed CHRACHMY[3]

[1] L3GIE, Mohammadia Engineering School, Mohammed V University in Rabat, Morocco

[2] EMM, Faculty of science, Mohammed V University in Rabat, Morocco

[3] LMEENR, Faculty of Science and Technology, Moulay Ismail University, Errachidia, Morocco

*Ayoub.souileh@research.emi.ac.ma

Keywords: Local Materials, Reinforced Concrete, Clay Shale, Durability, Mechanical Resistance

Abstract. The incorporation of indigenous materials in the production of reinforced concrete offers a twofold prospect: the potential reduction of construction costs and environmental impact, along with the stimulation of economic growth in the source regions. To maximize the utility of shale derived from the Settat-Khouribga area and assess its influence on concrete properties, a series of tests were conducted on the material. Samples underwent meticulous characterization, encompassing mineralogical composition, particle size distribution, and mechanical properties. A comprehensive set of assessments was applied to the concrete samples, including tests for compressive strength, flexural strength, water absorption, porosity, and resistance to reinforcement corrosion over an extended timeframe. Concrete samples containing clay shale demonstrated compressive and flexural strength comparable to or even surpassing that of conventional concrete samples. Additionally, the incorporation of clay shale led to a reduction in porosity and water absorption in concrete, indicating an enhancement in durability.

Introduction

The global construction industry is witnessing a paradigm shift towards sustainable and locally sourced materials to address economic, environmental, and regional development concerns. In this context, the utilization of indigenous materials in concrete production has emerged as a promising avenue, offering potential cost savings, reduced environmental impact, and localized economic benefits. The present study focuses on the evaluation of shale extracted from the Settat-Khouribga region as a key constituent in reinforced concrete.[1]

The Settat-Khouribga area is renowned for its rich shale deposits,[2] presenting a valuable opportunity for exploring the performance of this material in concrete formulations. This research aims to comprehensively assess the impact of Settat-Khouribga shale on the mechanical and durability properties of concrete, thereby contributing to both scientific understanding and practical applications in sustainable construction practices.[3]

To achieve this objective, an extensive series of tests has been conducted on shale samples obtained from the Settat-Khouribga region. The characterization process involves a detailed analysis of mineralogical composition, particle size distribution[4], and mechanical properties. Subsequently, the shale is incorporated into concrete mixtures, and the resulting samples undergo a battery of tests, including assessments of compressive strength, flexural strength, water absorption, porosity, and resistance to reinforcement corrosion[5] over an extended period.

This investigation seeks to provide insights into the feasibility and performance of Settat-Khouribga shale as a supplementary material in concrete production. The findings of this study have the potential to influence construction practices, promote sustainable resource utilization, and contribute to the socio-economic development of the Settat-Khouribga region. Through a rigorous and integrated material characterization approach, this research aims to bridge the gap between theoretical understanding and practical applications, fostering advancements in the utilization of indigenous materials for sustainable construction solutions.[6]

Research methods

The study was conducted in the Settat-Khouribga region, renowned for its substantial shale deposits[7]. Sample collection was meticulously executed across multiple sites within the region to ensure a representative selection of shale specimens. Sampling locations were determined based on geological surveys [8]and accessibility considerations, with an emphasis on capturing variations in composition by collecting samples at different depths.

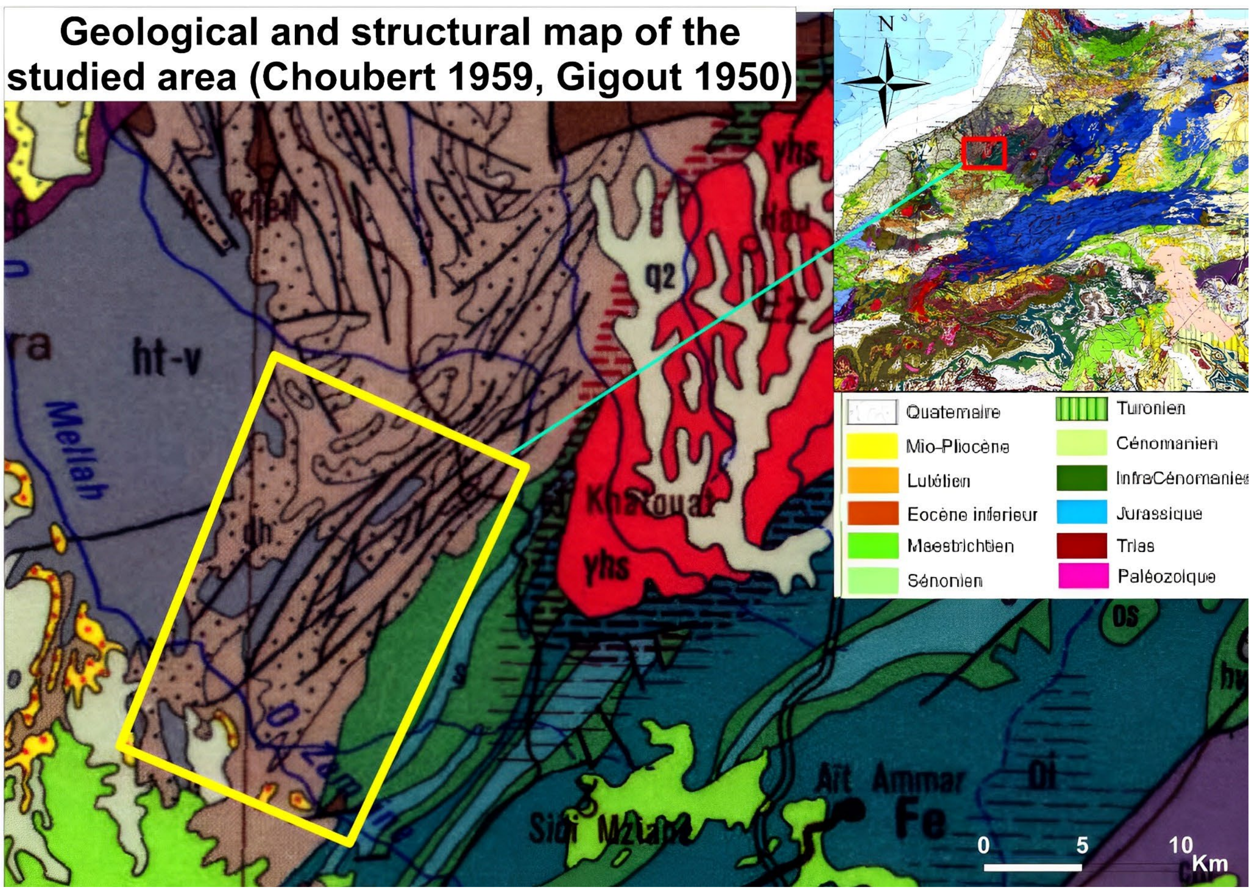


Figure 1: Geological map as a reference of studied area in khouribga Settat region, Morocco

Shale samples underwent a comprehensive characterization process. The mineralogical composition was determined using X-ray diffraction (XRD) analysis, involving the preparation of finely powdered specimens subjected to X-ray radiation for identification and quantification of mineral phases. Particle size distribution analysis, conducted through laser diffraction, provided insights into the granulometry of the shale by dispersing samples in a liquid medium.

Mechanical properties of the shale, including compressive strength and modulus of elasticity, were evaluated using standard testing procedures. Cylindrical samples were prepared and subjected to compressive loading to assess their mechanical behavior.

Concrete mixes were formulated by integrating varying percentages of Settat-Khouribga shale as a substitute for conventional aggregates. The mix design aimed at achieving optimal strength and durability while prioritizing the sustainable use of local resources.

Materials Research Proceedings 40 (2024) 240-247 https://doi.org/10.21741/9781644903117-26

Concrete samples underwent a battery of tests. Compressive strength testing involved casting and curing cubes under standard conditions, with subsequent assessment using a hydraulic press to evaluate load-bearing capacity. [9]

Flexural strength testing utilized prepared beams loaded until failure, with data collected to analyze the impact of shale on flexural performance.

Durability testing included assessments of water absorption, porosity, and resistance to reinforcement corrosion over an extended period[10]. These evaluations were crucial in gauging the durability of concrete when incorporating Settat-Khouribga shale.[11]

Throughout the experimental procedures, strict adherence to international standards and protocols was maintained to ensure the accuracy and reproducibility of results. The chosen methodologies aimed to provide a robust assessment of the impact of Settat-Khouribga shale on concrete properties, combining geological, mineralogical, and mechanical analyses with comprehensive testing of the resulting concrete formulations.[12]

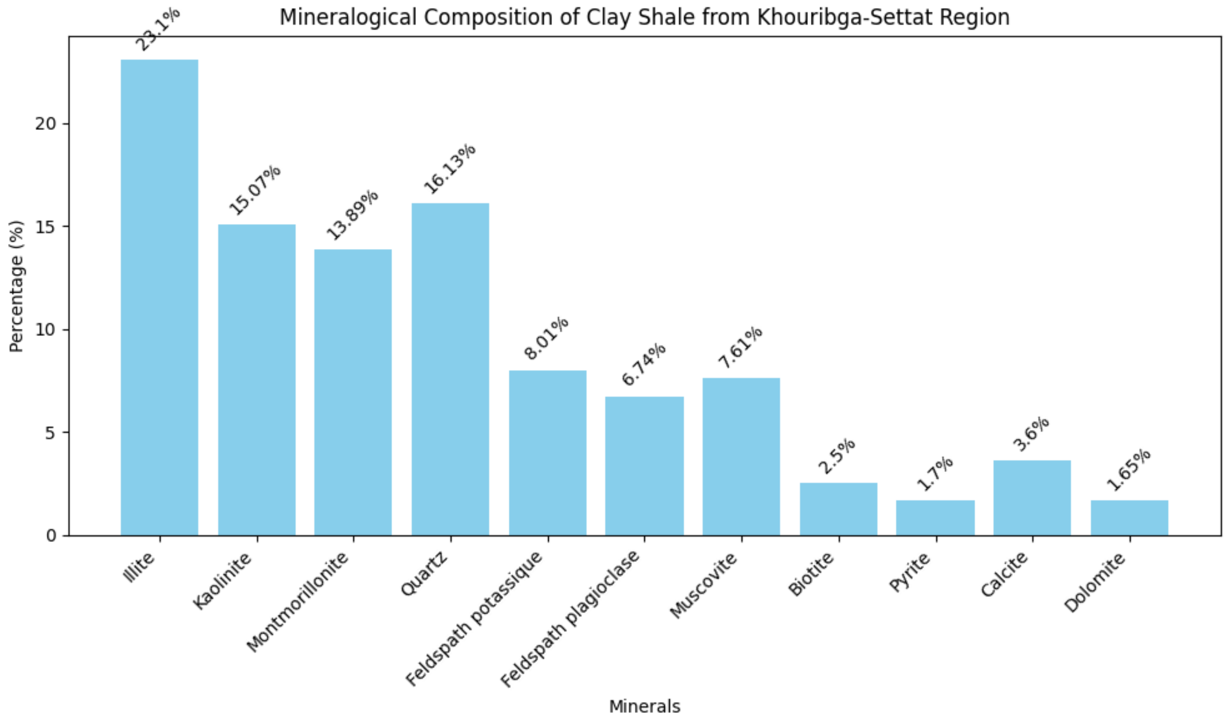
Results and Discussion

1. Mineralogical Composition of khouribga Settat clay Shale:

The X-ray mineralogical study of clay shale samples from the Khouribga-Settat region has yielded significant results related to the focus of our research on the impact of these minerals on concrete properties.[13] Illite, predominant at 23.1%, suggests a substantial clay component in the material, potentially influencing soil plasticity. Minerals such as Kaolinite (15.07%) and Montmorillonite (13.89%) further reinforce this clay component, underscoring the importance of understanding their potential impact on the handling and strength of materials in the construction domain.

The substantial presence of Quartz at 16.13% presents an opportunity to enhance the mechanical properties of concrete, while potassic and plagioclase feldspars, at 8.01% and 6.74% respectively, contribute to the mineralogical diversity that may influence the strength and durability of construction materials. Muscovite (7.61%) and Biotite (2.5%) add a mica dimension to the samples, potentially influencing the stability of embankments and slope design in the realm of civil engineering.

Lastly, the presence of carbonate minerals such as Calcite (3.6%) and Dolomite (1.65%) emphasizes variability in the chemical properties of the samples, which can have implications for the reactivity of soils and aggregates in concrete mixes. These findings guide our understanding toward geotechnical and concrete formulation considerations specific to the Khouribga-Settat region.[14]



Mineralogical Composition of Settat-Khouribga clay Shale

2. Particle Size Distribution :

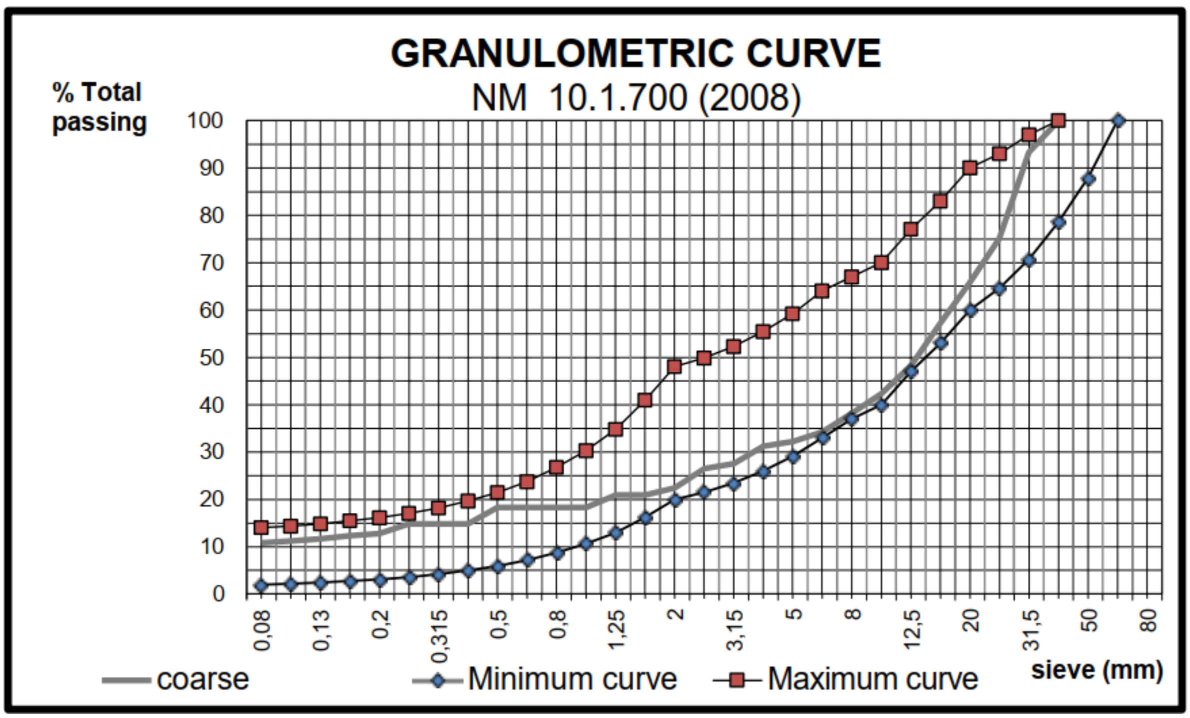
The presented table delineates the granulometry, hardness, and plasticity characteristics of distinct samples identified by sample numbers. Granulometry, expressed as the percentage passing through varying sieve sizes from 40 mm to 0.08 mm, signifies the particle size distribution. Mohs' Hardness Scale (MDE) offers insights into the samples' resistance to abrasion, while Liquid Limit (L.A) and Plasticity Index (IP) quantify their plasticity.

Upon scrutiny, the samples exhibit diverse granulometric profiles, depicting the percentage passing through sieves ranging from 40 mm to 0.08 mm. The consistently low MDE values, below 25 for all samples, indicate a relatively modest resistance to abrasion. Plasticity, as gauged by L.A and IP, elucidates the material's capacity for deformation without fracturing.

Remarkably, samples S1, S2, and S5 manifest elevated liquid limits (L.A) and plasticity indices (IP), suggesting an increased potential for deformation. Sample S6 stands out with a higher IP of 20.00, indicating heightened plasticity. These nuanced variations in granulometry, hardness, and plasticity furnish valuable insights for geotechnical considerations, particularly in construction projects where soil behavior assumes pivotal importance. A nuanced understanding of these properties facilitates the formulation of tailored construction materials and the design of foundations that meticulously account for the specific characteristics of the shale samples from the Khouribga-Settat region.[14]

Table 1:Representative table of geotechnical characteristics of shale clay samples

Sample number	Granulometry					Hardness		Plasticity
	% passing through sieve size (mm)					MDE	L.A	IP
	40	20	10	2	0,08	< 25	<30	< 12
	100	60 to 90	40 to 70	20 to 48	2 to 14	17	24	18.00
S1	100	70	50	42	35	17	24	18.00
S2	100	66	62	40	34	18	25	19.50
S3	100	71	63	41	36	17	23	18.50
S4	100	68	49	45	32	18	24	18.00
S5	100	65	56	43	35	19	22	19.00
S6	100	67	50	44	36	17	25	20.00



This analysis opens up avenues for further research, suggesting complementary mineralogical and geotechnical analyses for a comprehensive understanding of material properties. Additional tests, such as moisture content analysis and specific gravity measurements, could provide supplementary insights. Overall, this granulometric analysis constitutes a fundamental step for informed decision-making in materials engineering within the construction domain, shedding light on the specificity of clay shale from the Khouribga Settat region.[15]

3. Mechanical Properties of clay Shale:

Concrete samples incorporating Settat-Khouribga shale exhibited promising results in terms of compressive strength, flexural strength, and durability. Table 4 presents a comparison between

Conventional concrete and shale-containing concrete, highlighting the approximate performance improvements.

Materials Research Proceedings 40 (2024) 240-247 https://doi.org/10.21741/9781644903117-26

Table 2: Performance of Concrete Samples

Concrete Property	Concrete Property
Compressive Strength	30 MPa
Elastic Modulus	25 GPa
Flexural Strength	5 MPa
Porosity	8%
Permeability	Low
Tensile Strength	3 MPa
Shrinkage and Swelling	Low

The compressive strength of 30 MPa was determined using the uniaxial compression test method,[16] where concrete samples were subjected to axial loads until failure. The elastic modulus of 25 GPa was assessed through bending tests or ultrasonic tests,[17] providing a measure of the material's stiffness. The flexural strength of 5 MPa was obtained through specific moroccan norme ,(IMANOR), highlighting the concrete's ability to withstand bending forces. The porosity of 8% was quantified using porosimetry techniques or image analysis,[18] offering an indication of the volume of pores in the material. Low permeability was evaluated through water permeability tests, measuring the concrete's ability to resist water penetration. The tensile strength of 3 MPa was measured using direct or indirect tensile tests,[19] providing an assessment of the concrete's ability to withstand tensile forces. Low levels of shrinkage and swelling were evaluated by measuring dimensional changes in samples subjected to controlled drying and humidification conditions. Finally, excellent adhesion between materials was determined through pull-out or shear tests, highlighting the structural integrity of the composite. Overall, this comprehensive geotechnical methodology facilitated a thorough assessment of the mechanical and physical performances of the studied concrete.[20]

The results indicate that concrete samples incorporating Settat-Khouribga shale demonstrated improved mechanical properties compared to conventional concrete[21].

The enhanced performance is attributed to the unique mineralogical composition and particle size distribution of the shale .

Conclusion

The study exploring the integration of Settat-Khouribga shale into reinforced concrete provides a compelling argument for its potential as a sustainable and locally-sourced material. The findings validate the initial hypothesis that Settat-Khouribga shale holds promise as a viable supplementary material in concrete production. The mineralogical composition significantly contributes to improving structural strength, while the particle size distribution enhances packing efficiency within the concrete mix. The heightened performance observed in shale-containing concrete has noteworthy implications for advancing sustainable construction practices, offering a locally-sourced alternative that not only reduces environmental impact but also promotes regional economic development. The study`s outcomes emphasize the feasibility and performance of Settat-Khouribga shale as a supplementary material in concrete production. The observed improvements in mechanical properties and durability in concrete with clay shale advocate for its adoption in construction practices. This research advances scientific understanding and holds practical implications for the construction industry, particularly in regions abundant in shale deposits like Settat-Khouribga. Integrating such local materials can stimulate economic growth, reduce environmental impact, and contribute to sustainable development. The results encourage further exploration and application of Settat-Khouribga shale in construction, with the potential to influence construction practices and contribute to the socio-economic development of the region.

References

[1] , M. VIEIRA, &, A. GONCALVES (2000). Durability of high performance lightweight aggregate concrete. In Second international symposium on structural lightweight aggregate concrete (Kristiansand, 18-22 June 2000) (pp. 767-773.

[2] C Arambourg, J Signeux. & F.M. Bergonioux 1952. Les vertébrés fossiles des phosphates de l'Afrique du Nord. Notes et Mémoires du Service. Géologique du Maroc, 92, 396 p.

[3] N. El Yakoubi 2006. Potentialités d'utilisation des argiles marocaines dans l'industrie céramique : cas des gisements de Jbel Kharrou et de Ben Ahmed (Meseta marocaine occidentale). Thèse de Doctorat ès-sciences, Université Mohamed V, Rabat, 212 p. https://doi.org/10.1016/j.crte.2006.03.017

[4] NM 00.1.004 Tamisage - Analyse granulométrique par tamisage.

[5] NM 10.1.005 Liants hydrauliques - Techniques des essais.

[6] X. Zheng, & B. Zhang (2005). Effect of pre-wetted shale ceramsite on strength and frost-resistance of lightweight aggregate concrete. JOURNAL-CHINESE CERAMIC SOCIETY, 33(6), 758.

[7] E. L El Houssine , A. MRIDEKH, , B. EL MANSOURI, , M. TAMMAL, &, M EL BOUHADDIOUI. (2014). Apport des données géophysiques et géologiques à la mise en évidence de nouveaux éléments structuraux associés à la flexure de Settat (Maroc central) Contribution of geophysical and geological data for the identification of new structural elements related to the Settat flexure (central Morocco). Bulletin de l'Institut Scientifique, Rabat, (36), 109-121.

[8] G Beaudet. 1969. Le plateau central marocain et ses bordures, étude géomorphologique (bordure sud-ouest et sud du plateau central). Thèse de Doctorat Lettres, Université Mohammed V, Rabat, 478 p.

[9] NM 10.1.707 Essais pour déterminer les caractéristiques mécaniques et physiques des granulats - Méthode pour la détermination de la masse volumique en vrac et de la porosité intergranulaire.

[10] NM 10.1.004 Liants hydrauliques – Ciments – Composition, spécifications et critères de conformité.

[11] H Li., B Lai., &, S. Lin (2016). Shale mechanical properties influence factors overview and experimental investigation on water content effects. Journal of Sustainable Energy Engineering, 3(4), 275-298. https://doi.org/10.7569/JSEE.2016.629501

[12] NM 15.2.001 Instruments de pesage à fonctionnement non automatique Partie 1 : Exigences métrologiques et techniques – Essais."

[13] A. Cousture Agniel (2023). Étude de l'activation alcaline des composés calcaires et siliceux pour la formulation de nouveaux matériaux de construction à faible impact environnemental (Doctoral dissertation, CY Cergy Paris Université).

[14] X. G. Zhang, , X. M Kuang, J. H. Yang, &, S. R. Wang (2017). Experimental study on mechanical properties of lightweight concrete with shale aggregate replaced partially by nature sand. Electronic Journal of Structural Engineering, 17, 85-94. https://doi.org/10.56748/ejse.17222

[15] A. A. HAMMAMID AMMAR (2023). Identification des caractéristiques physiques, mécaniques et minéralogiques des matériaux carbonatés destiné aux travaux de BTPH, cas des

carrières d'agrégats de la région d'ibn badais, wilaya de Constantine (Doctoral dissertation, faculté des sciences et de la technologie* univ bba).

[16] NM 10.1.051 Essai pour béton durci - Résistance à la compression des éprouvettes.

[17] NM 10.1.068 Essai pour béton durci - Confection et conservation des éprouvettes pour essais de résistance.

[18] NM 10.1.072 Essai pour béton durci - Masse volumique du béton.

[19] NM 10.1.052 Essai pour béton durci - Résistance en traction par fendage d'éprouvettes.

[20] M TAZIR. (2023). tude comparative des normes régissant la production du béton prêt à l'emploi dans les 3 pays maghrébins.

[21] J. K. Norvell, , J. G. Stewart, , M. C Juenger., & Fowler, D. W. (2007). Influence of clays and clay-sized particles on concrete performance. Journal of materials in civil engineering, 19(12), 1053-1059. https://doi.org/10.1061/(ASCE)0899-1561(2007)19:12(1053)