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Valorización de relaves de mineral de oro de la mina Amesmessa en mortero de cemento: propiedades mecánicas, químicas y de microestructura.
Valorization of gold ore tailing from Amesmessa mine in cement mortar: mechanical, chemical and microstructure properties.

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Resumen-- **La necesidad de responder a los problemas ambientales causados por los rechazos mineros, muchos enfoques llevados a cabo para resolver estos problemas. En este trabajo, se estudió el relave de mineral de oro proporcionado por la mina Amesmessa como sustitución en el mortero de cemento. Las cantidades de sustitución estudiadas fueron 0, 10, 20, 30 y 40 % del cemento en peso. Se relevó la composición mineralógica de las principales fases de la hidratación del cemento. Se realizaron pruebas experimentales como la compresión, la porosidad y la absorción de agua. Las pruebas revelaron que la sustitución del cemento al 10% es la cantidad óptima para sustituir el cemento. Se demostró una resistencia a la compresión de 33 Mpa, una porosidad de 10,31% y una absorción de agua de 4,83%. Estos valores se acercan a los de las muestras de referencia. Esta sustitución permite preservar el medio ambiente desde dos puntos de vista, mediante la valorización de los residuos de mineral de oro y la disminución de la emisión de CO2 con la disminución de la producción de cemento.**

Palabras clave— Mortero; relaves de mineral de oro; propiedades mecánicas; porosidad.

Abstract— **The need to respond the environmental problems causing by mining rejects, many approaches carried out to resolve these problems. In this work, we studied the gold ore tailing provided by Amesmessa mine as replacement in cement mortar. The substitution amounts studied 0, 10, 20, 30, and 40 % of cement in weight. The mineralogical composition was relieved the principal phases of the cement hydration. Experimental tests carried out such as compressive, porosity, water absorption. The tests revealed that the replacement of cement at 10% percent is the optimum amount to replace cement. It showed 33 Mpa of compressive strength, 10.31% porosity, 4.83% water absorption. These values are so close to those of reference samples. This substitution allows preserving the environment from two sides, by valorizing the gold ore tailing and diminishing the CO2 emission with diminishing the cement production.**

Index Terms— Mortar; gold ore tailing; mechanical properties; porosity.

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I. INTRODUCTION

INDUSTRIAL activities, human consumption habits and linear process systems are currently generating more and more Waste and by-products. The foundation of the community waste management policy is to minimize waste generation by reducing waste generated at the source, promoting recycling and reuse, and reducing waste generation. Apply clean technology to deal with pollution caused by waste (COM, 2006; Elías, 2009). Therefore, once these residues are produced, a series of reusable technologies can be used. This is the so-called way of the three "R" Recycle, recycle and reuse (Eliche-Quesada, 2012). There are several research lines dedicated to reducing the use of cement in mortar by replacing cement with alternative industrial by-products (Ming; Vandna; Borinaga, 2021).

In fact, in the past few decades, several studies have been conducted to reuse or recycle these wastes as substitutes and cheaper raw materials (Bondioli, 2000). It turns out that the massive reuse of various wastes can be used as a substitute for raw materials. S stone powder and marble sludge as a substitute for fine aggregate were studied by S.M. Hameed et al. (2009). In two different studies, limestone waste and alum sludge have been used as a substitute for fine aggregate (Kaosol, 2009; Carlos, 2010; Makhloufi, 2014).

The use of mine tailings in construction practices is mentioned in the literature. Such as, the mine wastes of Western Australia in embankment construction (Kuranchie, 2013).

Two types of wastes from mining industry which are copper mine tailings (MT) and low-calcium flash-furnace copper smelter slag (SG), have been promising in genie civil applications (Ahmari, 2015). Copper slag as replacement of were studied in a high-performance concrete Al-Jabri, 2009). The development of alkali-activated binders using waste mud from tungsten mine were carried out in another investigation revealed the possibility to use this waste as an inert material to develop binders (Fernando, 2010).

On the other hand, several authors have studied the possibility of using gold tailings as raw materials in different fields (such as glass fiber, geopolymers, glass-ceramic granite, bricks, and ceramic fields) and as additives in mortar (Youngjae, 2018; Kiventerä, 2016; Roy, 2007; Baziz, 2021; Ince, 2019; Kunt, 2015).

In our research, we focus on the impact of gold mine tailings instead of cement on the mechanical properties of mortar samples. It is rich in elements and can replace cement and sand. This method makes it possible to find industrial uses for this waste in the construction sector. Therefore, capturing the heavy metals in this waste into concrete can reduce its impact on the environment.

II. MATERIALS AND METHODS

A. Materials

The gold mine tailing (GMT) was sampled from Amesmessa mine. It was collected from the under stream of the treatment chain, after cyanide leaching of gold ore and the recovery of the gold. The samples of GMT were dried at 100 °C for 2 hours. The Cement used is CEM I, and standard sand in order to prepare mortar samples. The material is dried in an oven at 60°C and dried for 48 hours, then crushed and sieved through a 63μm sieve (larger powder fineness produces improvement). Nine samples were checked according to the standard (ASTM C109). The mentioned mixture incorporates the control sample (M0) and the other four samples (M10, M20, M30 and M40) with 10%, 20%, 30% and 40% waste products (WD) respectively. In this case, original waste is added instead of cement. The mixture consists of 225 ml of water (tap water or sewage), 450 g of OPC and 1350 g of standard sand CEN, with a water/binder ratio of 0.5 and a sand/cement ratio of 3%. The batching process includes dry homogenization of the material for 30 s. Then, add a certain amount of water to the bowl. Subsequently, resume mixing at low speed for another 30 s. Then, increase the speed of the stirrer to a medium level and keep it for the same time as above, and finally, complete the process by mixing at a medium speed for 60 s (ASTM C305). In the prism mold (4 cm x 4 cm x 16 cm). After molding, place them in a room at 23°C for 24 hours. Then demold and cure with water until the test ages. This is a very important practical significance, because the actual curing conditions are usually between dry air and water immersion.

B. Methods

Using a Philips X'Pert Pro automatic diffractometer equipped with master monochromatic, the main crystal phases in GMT, cement and sand can be qualitatively determined, and refined to determine the quantitative aspects.

The chemical composition of Philips Magix Pro (PW-2440) is used for the X-ray fluorescence (XRF) of the raw material.

The water absorption value is determined by According to ASTM Standard C373 (ASTM, 1994), the weight difference between the calcined sample and the water-saturated sample (immersed in boiling water for 2 hours). The bulk density is determined by the Archimedes method based on this the porosity was calculated (ASTM, 1994). The compressive and flexural strength of mortars is their bulk unit charge that resists breaking under the axial compressive strength. For this test, six fired samples were studied. The compressive strength test is carried out on the Suzpecar CME 200 SDC laboratory press according to the standard UNE-EN 772-1 (AENOR, 2002).

TABLE I
THE CHEMICAL COMPOSITION OF RAW MATERIALS

Oxides	SiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	Cr_2O_3	NiO	SO_3	ZnO	PbO	L.O.I
Cement (wt %)	19.86	4.62	3.05	0.10	1.3	61.94	0.23	1.17	-	-	4.3	-	0,123	1.32
GMT (wt %)	61.2	12.9	7.98	0.123	2.58	5.12	1.79	3.98	0.060	0.119	2.64	0.319	0.029	0.34
Sand (wt %)	98.50	4.62	3.05	-	0.3	0.12	0.02	0.07	-	-	0.01	-	-	36.32

III. Results and discussion

A. The chemical composition of raw materials

As it shown in the table 1, the chemical analysis of cement revealed the presence of lime (CaO) in great part as well as the presence of magnesium oxide (MgO) of a rate 1.55 wt % and for the 12.04 wt% for the sand as well as the presence of other oxides has low percentages. In other hand, the sand and GMT are mainly composed of SiO2 with 98.50 and 61.2 (wt %) respectively.

B. The mineralogical composition of raw materials

Fig. 1 shows the mineralogical composition of raw materials (GMT, Sand, and cement). GMT is composed by Quartz, Dolomite, Muscovite, Albite and pyrite. The sand is mainly composed by Quartz. In other hand, the cement contains Quartz, Albite and calcite as mineral phases.

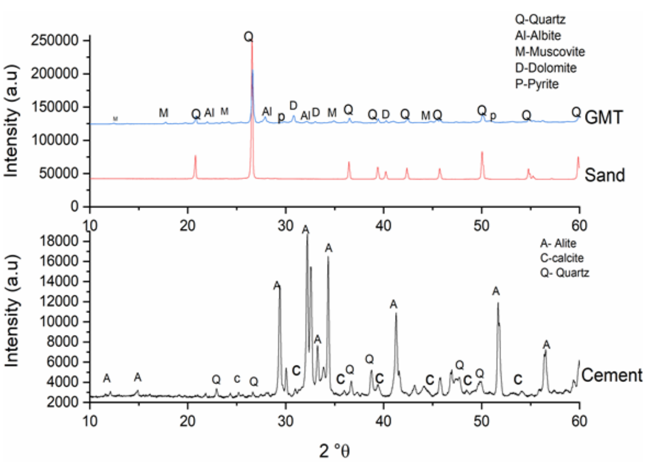

Fig. 1. The mineralogical phases of raw materials

C. Compressive and flexural strength

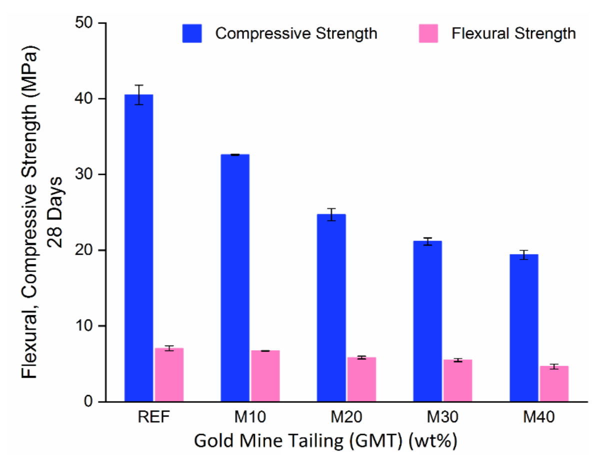

Fig. 2. Compressive and flexural strength of prepared mortar.

According to the results of 28-day compressive and flexural strength of mortars developed by substituting cement with gold ore processing tailings, which are shown in Fig. 2, compressive and flexural strengths decreased by substituting cement with gold ore processing tailings in a proportional way. The decrease in mechanical properties observed can be explained by the decrease in the percentage of cement in the mortars and the non-pozzolanic behavior of the tailings.

Compared to the reference mortar whose compressive strength is 40.50 MPa, the latter has decreased by almost 20% for the mortar M10 which recorded strength of 32.61 MPa and it reached half the strength of the reference for the mortar M40.

For the same formulations, the flexural strength, the control was about 7.76 MPa and decreased to reach 6.71 and 4.64 MPa for mortars M10 and M40, a decrease of 4.76 and 34% respectively. These results, which show a decrease in compressive and flexural strength, are in line with the results of research conducted on the substitution of cement by mine tailings.

D. Porosity

Fig. 3 shows the evolution of porosity of mortars developed by substituting cement at different percentage (10-20-30-40%), compared to the reference mortar, measuring the porosity at 7 days for a reference mortar we note a porosity of 12.36% as the substitution of cement the porosity increases with less than 1%, recorded for the reference for mortars M10 and M20 and 3.13 and 3.55 for M30 and M40.

The obtained porosity of the mortars at 28 days M10 and M20 of the order of 10.30 % and 10.56 % respectively which are close to the porosity of the reference mortar that is 10.29 %.

By increasing the percentage of incorporation of gold ore processing residues by 30 and 40 %, the porosity increases by 3.30 and 5.35 % respectively when compared to the reference mortar.

M10, M20 and Ref showed similar and close porosities whether in 7 or 28 days, which means that the substitution of cement up to 20% did not show significant changes in porosity. The increase in porosity can be explained by the reduction of the volume of hydrated products from cement hydration which decreases with the substitution rate (Toubal, 2019; Zhao, 2018).

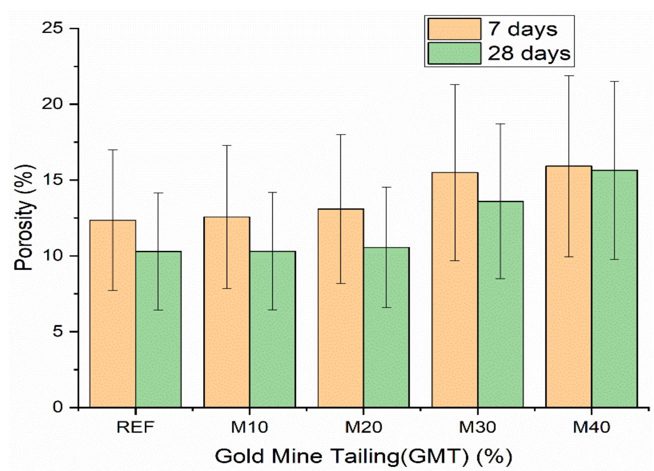

Fig. 3. Porosity of prepared mortars.

E. Water absorption

The results of the water absorption test of the mortars made at 7 and 28 days shown in Fig. 4 indicate that the values of the absorption rate increase linearly with the increase of the percentage of substitution of cement by residues. The lowest absorption rates are obtained for mortars made with 10% and

20% residue incorporation (M10 and M20) are respectively 5.91, 6.17% at 7 days and 4.84, 4.94% at 28 days, i.e. 0.04 and 0.10% higher than the reference sample at 28 days. The mortars containing 30 and 40% residue show an increase in absorption rate whose values recorded at 28 days are 6.44 and 7.51% (M30 and M40), which can be justified by the distribution and pore size which can be explained by the non-uniform distribution of the residue due to the large amount which created weak areas like voids in the mortar matrix hence the increase in porosity (Li, 2004).

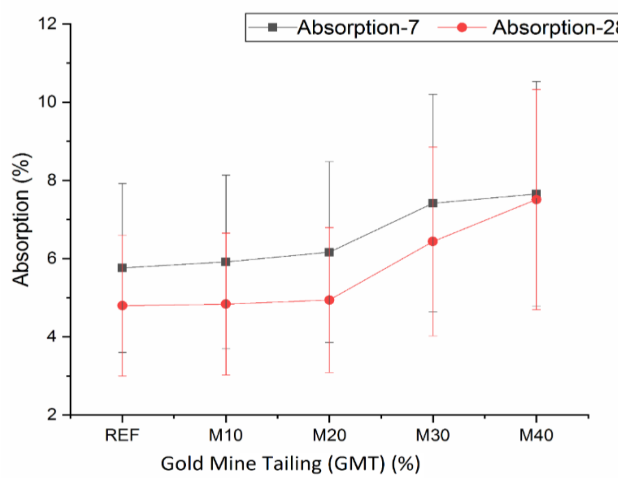

Fig. 4. Water absorption of prepared mortars.

IV. Conclusions

According to the results and their discussion, the optimum percentage to incorporate GMT in mortar preparation is 10 (wt %) as substitution of cement. Compared to the reference mortar whose compressive strength is 40.50 MPa, the latter has decreased by almost 20% for the mortar M10 which recorded strength of 32.61 MPa.

But it remains to say that it represents good strength. The obtained porosity of the mortars at 28 days M10 the order of 10.30 % and which are close to the porosity of the reference mortar that is 10.29 %. The lowest absorption rates are obtained for mortars made with 10% residue incorporation (M10 and M20) are respectively 5.91% at 7 days and 4.84% at 28 days.

References

S. Ahmari, K. Parameswaran, L. Zhang, Alkali activation of copper mine tailings and low-calcium flash-furnace copper smelter slag. J. Mater. Civ. Eng. 27(6), (2015) 04014193.

K.S. Al-Jabri, M. Hisada, S.K. Al-Oraimi, A.H. Al-Saidy, , Copper slag as sand replacement for high performance concrete (2009).

ASTM, ASTM C373 – Test Method for Water Absorption, Bulk Density, Apparent Porosity, and Apparent Specific Gravity of Fired Whiteware Products. American Society for Testing and Materials (1994a.).

A. Baziz, N. Bouzidi, D. Eliche-Quesada, Recycling of gold mining reject from Amesmessa mine as ceramic raw material: microstructure and mechanical properties. J. Environ Sci Pollut Res (2021).

F. Bondioli, , L Barbieri, T. Manfredini, Grey ceramic pigment (Fe, Zn) Cr2O4 obtained from industrial fly-ash. Journal of Tile & Brick Int., (2000), 16, 246-248.

R.Borinaga- Treviño, J. Cuadrado J. Canales, E. Rojí, Lime mud waste from the paper industry as a partial replacement of cement in mortars used on radiant floor heating systems, Journal of Building Engineering Available online 13 March 2021, 102408.

A. Carlos, I. Masumi, M. Hiroaki, M. Maki, O. Takahisa, The effects of limestone aggregate on concrete properties. Construct. Build. Mater., (2010), 24 2363–2368.

X. Elías, Reciclaje de residuos Industriales. Residuos sólidos urbanos y fangos de depuradora. España: Díaz de Santos,(2009).

D. Eliche-Quesada, F. A.Corpas-Iglesias, L.Pérez-Villarejo, F. J. Iglesias-Godino, Recycling of sawdust, spent earth from oil filtration, compost and marble residues for brick manufacturing. Construction and Building Materials, (2012), 34, 275 .

European Commission. Report from the commission to the council and the European parliament on implementation of the community waste legislation. COM 2006, 406 (final, Brussels), (2006).

P.T. Fernando, C.G. Joao, J. Said, Durability and environmental performance of alkali-activated Tungsten mine waste mud mortars. J. Mater. Civ. Eng. 22 (9), 897e904 (2010).

S.M. Hameed, A.S. Sekar, Properties of green concrete containing quarry rock dust and marble sludge powder as fine aggregate. ARPN Journal of Eng. and Applied Scie. (2009), VOL. 4 (4) 83–89.

C. Ince, Reusing gold-mine tailings in cement mortars: Mechanical properties and socio-economic developments for the Lefke-Xeros area of Cyprus. Journal of Cleaner Production, (2019), 238, 117871.

T. Kaosol, Reuse Water Treatment Sludge for Hollow Concrete Block Manufacture. International Concrete on Science. Technology and Innovation for Sustainable Well Being (STISWB), (2009), pp. 23–24.

J. Kiventerä, L. Golek, , J. Yliniemi, V. Ferreira, , J. Deja , M. Illikainen, Utilization of sulphidic tailings from gold mine as a raw material in geopolymerization. International Journal of Mineral Processing (2016).

K. Kunt, Utilization of Bergama Gold Tailings as an Additive in the Mortar. Celal Bayar University Journal of Science, Volume 11, Issue 3, (2015).

F.A. Kuranchie, S.K. Shukla, D. Habibi, Mine wastes in western Australia and their suitability for embankment construction. In: Meehan, C.L. (Ed.), Geo-Congress ASCE. Geotechnical Special Publications, San Diego, California (2013).

H. Li, H. Xiao, J. Yuan, J. Ou, Microstructure of cement mortar with nanoparticles, Compos. B 35 (2004), 185–189, Kustermann A., Keuser M., The influence of steel fibers content in concrete on the plastic properties of composite, 6th Symposium on Fibre-Reinforced Concretes 2004, 1217

– 1226.

Z. Makhloufi, T. Bouziani, M. Bederina, M. Hadjoudja , Mix proportioning and performance of a crushed limestone sand-concrete. Journal of Building Material and Structure (2014), 10–22.

Z. Ming, I. GuoTung-Cha, P. ChiSun, Highly-efficient green photocatalytic cementitious materials with robust weathering resistance: From laboratory to application, J. Environmental Pollution, (2021), Vol. 273, 116510.

S. Roy, GR. Adhikari, RN. Gupta Use of gold mill tailings in making bricks: a feasibility study, J. Waste Manag Res (2007), 25:475–482.

N., Toubal Seghir, M. Mellas, Ł. Sadowski, A. Krolicka, A. Zak, The Effect of Curing Conditions on the Properties of Cement-Based Composites Blended with Waste Marble Dust. JOM (2019), 71, 1002–1015.

UNE EN 772-1, Methods of test for masonry units – Part 1: Determination of compressive strength (2002).

C. Vandna , N. Satya Pal , Pt-sensitized MoO3/mpg-CN mesoporous nanohybrid: A highly sensitive VOC sensor,J. Microporous and Mesoporous Materials. Volume 315, 110906.

K. Youngjae, K. Minseuk ,S. Jungsoo, P. Hyunsik, Applicability of gold tailings, waste limestone, red mud, and ferronickel slag for producing glass fibers. Journal of Cleaner Production, Volume 203,(2018). Pages 957-965.

Z. Zhao, M. Benzerzour, N. E. Abriak, D. Damidot, L. Courard, D., Wang, Use of uncontaminated marine sediments in mortar and concrete by partial substitution of cement. Cement and Concrete Composites, 93, (2018), 155-162.