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New formulation of the matrix conditioning of radioactive waste compounds by Resins Exchanges Ions (MBD-15)

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ABSTRACT: With the aim of optimizing the formulation of the matrix of the conditioning of Resins exchanges of ions (MBD-15) considered as radioactive waste generated by the nuclear reactor TRIGA MARK II of CENM, on one hand we realized several essays by fixing the percentage of cement and by modifying the percentages of resins to be confined (0 %, 4 %, 6 %, 8 %, 10 %, 12 %, and 14 %) and that some water. On the other hand, we realized another essay to illustrate the role of an aggregate such as the sand in the matrix of the cement. The moderate answer of all the realized essays is estimated by the compression resistance of the matrix after a time of 7 days, 14 days and 28 days of seclusion. The obtained results raise us that the maximum of the quantity of the REI, which we can incorporate into a formulation without the parcel loses its resistance is 12 %. The addition of an aggregate in the matrix of cement increases the compression resistance of this one.

KEYWORDS: Radioactive waste, cement, grading analysis, radioactive waste conditioning, compression resistance, radio-nuclides.

1 INTRODUCTION

The conditioning consists in converting the radioactive waste in a solid shape, in en former in containers, and / or to immobilize him by solidification, envelope or in capsule sealing to limit the possibilities of migration or dispersal of radio-nuclides during the operations of handling, transport and storing [1].

The Exploitation Unit of the radioactive Waste of the Nuclear research establishment of adopted the conditioning of liquid and solid radioactive waste such as the Resins Exchanges of Ions (REI), after their characterization [2], in matrices of cement, to show solidarity the whole waste and form so a parcel presenting characteristics improved for a long-term management [3].

Knowing that in the place of storing, parcel of packaged resins is stacked with regard to another parcel according to their weight, what can provoke the collapse of these parcels. The Wight of the parcel acts of a compressive force on those who are down, where from the importance of test some compression resistance. This brought to us to demonstrate experimentally the variation of the compression resistance of test tubes formed by a formulation with cement and with REI.

2 MATERIALS AND METHODS

2.1 USED MATERIALS

2.1.1 PRESS OF TYPE CARVER 4350. L

It is a manual hydraulic press. She allows determining the compression resistance of the matrix from the show strength and according to the surface of test tubes.

2.1.2 MIXER OF TYPE 3R

It is the device which assures a uniform mixture, he is of an essential importance for the quality of the process of preparation of test tubes. He allows obtaining from way constancy a mixture of a big homogeneity while reducing the duration of kneading.

2.1.3 COLUMN OF SIEVE OF TYPE 3R

This device allows determining the distribution of the mass of the particles of the sand to the dry state according to their dimension.

2.1.4 CEMENT

The used cement CPJ 45 is cement the technical characteristics of which are in accordance with the Moroccan standard NM 10.1.004. The CPJ 45 is a cement compound Portland, resulting from the grinding:

- Clinker (70 %).
- The 100% complement to one or several secondary constituents such as fillers, pozzolana or fly ash.
- The gypsum (CaSO4. 2 H2O), to regulate the setting time of the concrete [4].

2.1.5 SAND

The used sand is generally siliceous or silico-calcareous; her size grading is presented in the figure 7. The dosages will be made in weight rather than in volume as it is often the case, to avoid the errors of dosage. The sand must be dry [5].

2.2 METHOD OF PREPARATION OF TEST TUBES

The cement is introduced in the first one into the bowl of the mixer, then the REI, followed by progressive addition of volume of water to help with its absorption, and avoid the overflowing of the mixture. The agitation lasts 200 seconds with an average speed, the duration of kneading must be optimal, to obtain a homogeneous mixture which answers the standard (EN196-1) [6]. The mixture is poured into test tubes beforehand oiled with type Sika Fer M oil to facilitate their demanding, in continuation test tubes are submitted to a soft vibration by a typical vibrator Trakita VR 250D to eliminate the pockets of air.

The used test tubes are various dimensions:

- Cylindrical test tubes 10 cm in height and 5 cm in diameter.
- Cubic test tubes of 4x4x4 cm^3
- Prismatic test tubes of 8x4x4 cm^3

After demoulding, test tubes are preserved in ferries at ambient temperature.

2.3 METHOD OF GRADING ANALYSIS OF THE SAND

The grading analysis of sand is by means of a series of sieve fit some of the others, in an order such as the progress of openings is increasing of the bottom of the column upward (0.08 mm, 0.20 mm, 0.40 mm, 0.80 mm, 1.60 mm). In party subordinate we arrange a tight, form which will allow getting back fillers. A lid will be arranged at the top of the column to forbid any loss of sand during the sieving.

3 RESULTS AND DISCUSSIONS

The aim of this work is to enclose the maximum of the REI, considered as a radioactive waste [2], in a matrix where the sociable binder mainly being the cement while respecting the rheological characteristics and the physical appearances of the matrix. To accomplish the assigned goal, the formulations were carried away as follows:

FORMULATION N°1:

This formulation was realized by the exploitation unit of the radioactive Waste in association with the Lawrence Livermore's National Laboratory (LLNL).

Table 1. Formulation of a matrix of confinement of REI adopted by the UED [7]

Components	Cement	REI	Sand	Water
Fraction	49,3%	11,11%	19,45%	19,84%

FORMULATION N°2:

In the constantly improving the formulation of the matrix conditioning REI, the UED in collaboration with other scientific authorities [6] proposed the following formulation:

Table 2. Formula of the matrix of confinement of REI [8]

Components	Cement	REI	Water
Fraction	67 ,92 %	10 %	82,19 %

FORMULATION N°3:

To improve the conditions of seclusion, we continued the improvement of the formulation of the matrix, by maintaining the percentage of cement fixed and by modifying the percentages of resins in confined (0 %, 4 %, 6 %, 8 %, 10 %, 12 %, and 14 %) and that some water. The results are presented in the following table:

Table 3. Formulation of the cement matrix for the various realized essays

Essay n°	Percentages and mass of components					
	Cement		REI		Water	
	%	Mass (Kg)	%	Mass (Kg)	%	Mass (Kg)
1	66,66	0,444	0	0	33,33	0,223
2	67,92	0,453	4	0,029	28,19	0,189
3	67,92	0,453	6	0,044	26,19	0,176
4	67,92	0,453	8	0,058	24,19	0,163
5	67,92	0,453	10	0,066	22,19	0,148
6	67,92	0,453	12	0,079	20,19	0,135
7	67,92	0,453	14	0,092	18,19	0,122

Essay n°	Cement		Sand		REI		Water	
8	%	Mass (Kg)	%	Mass (Kg)	%	Mass (Kg)	%	Mass (Kg)
	50	2,668	25	1,334	0	0	25	1,334

The measured response of all the essays is the compressive test of resistance tubes (cylindrical, of 4x4x4 cm^3 and of 8x4x4 cm^3) after a time of 7 days, 14 days and 28 days of confinement.

3.1 CYLINDRICAL TEST TUBES

The following figure illustrates the cylindrical test tubes 10 x 5 cm^2

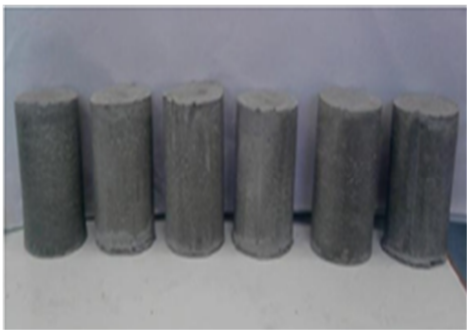

Fig. 1. Cylindrical test tubes

The fluctuation of the compression resistance in the time and depending on the theme of the cylindrical test tubes is illustrated in the figure 2

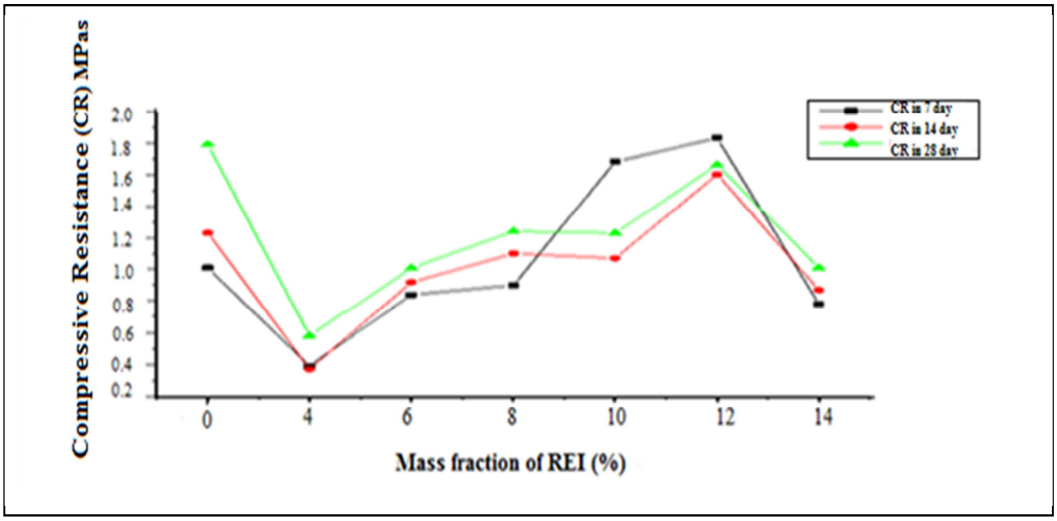

Fig. 2. Variation of the compression resistance of the cylindrical test tubes

The compression resistance increases, according to a percentage of the REI in the matrix to the 14 % where it decreases.

3.2 TEST TUBES OF 8X4X4 CM^3

The form of the cubic test tubes of 8x4x4 cm3 is illustrated in the figure 3:

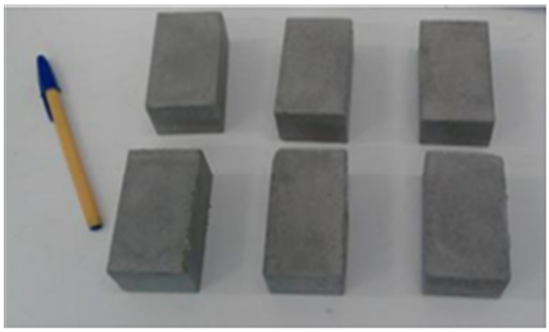

Fig. 3. Test tubes of 8x4x4 cm^3

The following graph illustrates the variation of the compression resistance of the test tubes of 8x4x4 cm3 for the various essays.

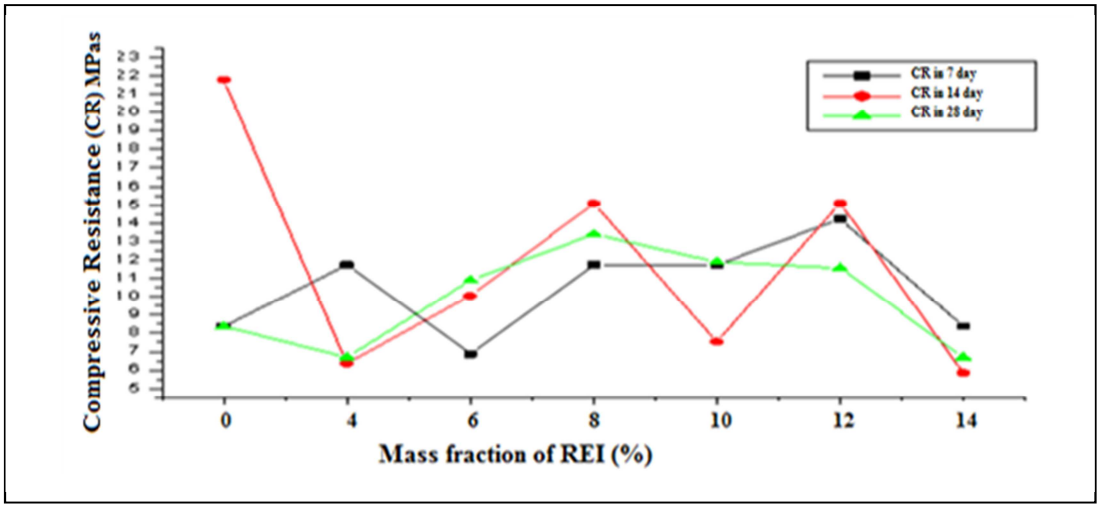

Fig. 4. Variation of the compression resistance of the cubic test tubes of 8x4x4 cm^3

Granting to the graph of the variance of the compression resistance of the matrices of 8x4x4 cm^3 we notice that:

- The compression resistance reaches a maximum for the times of seclusion 7 days and 14 days for a share of 12 % of REI, except for 28 days who presents an anomaly owed to the anatomy of the ground substance
- The compression resistance decreases have to allow 14 % of REI

3.3 CUBIC TEST TUBES OF 4X4X4 CM^3

The following image illustrates the cubic test tubes of 4x4x4 cm^3

Fig. 5. Cubic test tubes of 4x4x4 cm^3

The figure 6 presents the variation of the compressive resistance of cubic test tubes of 4x4x4 cm3 for the various essays.

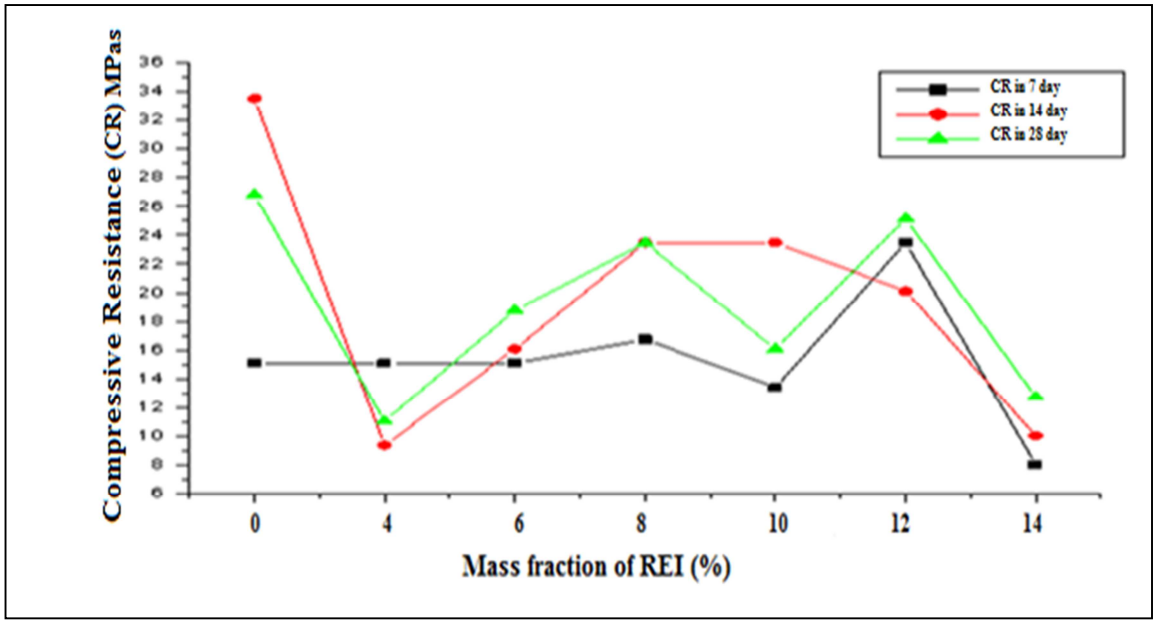

Fig. 6. Variation of the compressive resistance of cubic test tubes of 4x4x4 cm^3

According to the results illustrated in the figure 6 we let us notice that the compression resistance increases, according to REI to 14 % of REI where it decreases.

To illustrate the role of the sand in the matrix of cement, we have realized another essay compound of sand, cement and water (essay n°8). This essay will allow making a comparison with the essay n°1 which consists of cement and water.

The compression resistance of the essay n°8 and that of the essay n°1, for 7j, 14j and 28j of confinement is represented in the table 4.

Table 4. Formulation of the cement matrix for the various realized essays

	Test tubes			
	Prismatic of 8x4x4 cm^3		Cubic of 4x4x4 cm^3	
	Essay n°1	Essay n°8	Essay n°1	Essay n°8
Compressive strength in 7 days (MPa)	8,37	10,05	15,08	20,10
Compressive strength à 14 days (MPa)	21,78	18,43	33,51	25,46
Compressive strength à 28 days (MPa)	8,37	11,74	25,13	26,81

Granting to the results shown in the table4 above, we note that the compression resistance of the matrix containing the sand, later 7days, 14 days and 28 days of confinement, is generally superior to the one who does not hold back, what asserts that the summation of an conglomeration in the matrix augment its compression resistance.

3.4 GRADING ANALYSIS

The results of grading analysis of a representative quantity of sand used in the essay n°8 are presented in the figure7:

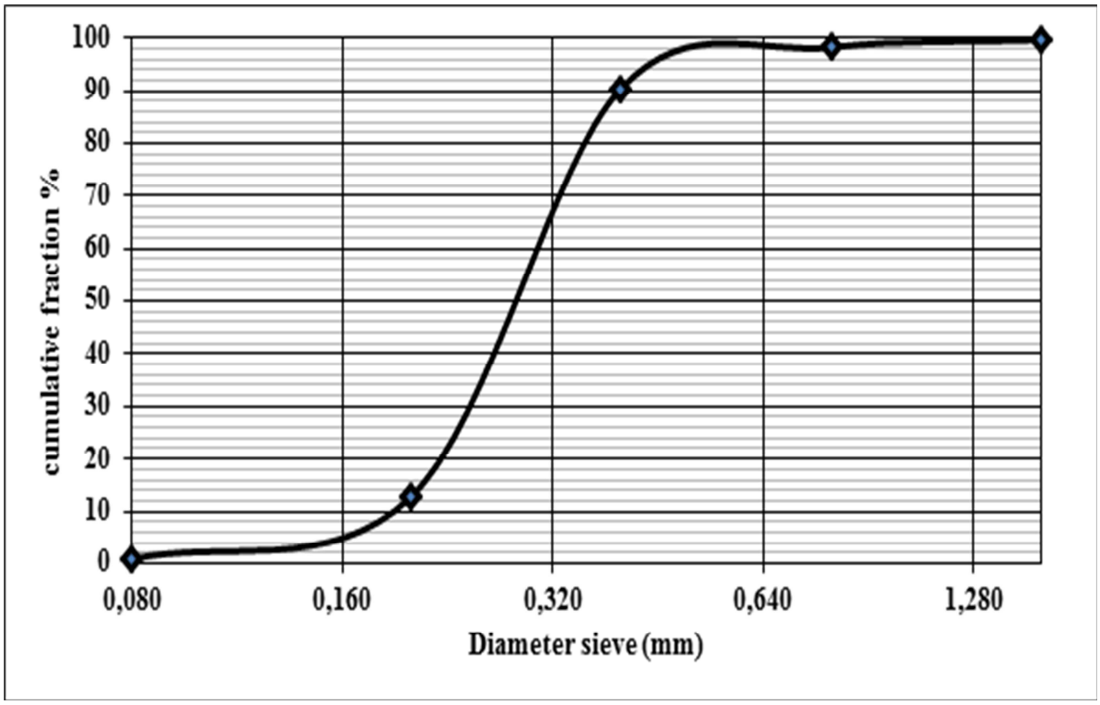

Fig. 7. Grading curve of sand

According to the grading curve, the majority of grains constituting the sand are medium-sized, what asserts that this sand is normalized (NM 10.1.020 (EN 196-1)).

4 CONCLUSION

The results of various essays realized for optimizing the formulation of the matrix confinement the REI show that the maximum quantity of REI, which may be incorporated into a formulation without the package losing its resistance is 12%. If this percentage is exceeded, the compressive strength of the matrix decreased. This new formulation used has increased the amount of REI confining whose percentage does not exceed 10% and minimize the number of barrels to store thereafter.

Also the results of essay n°8 confirmed that the summation of a conglomeration in the matrix such as the sand increases the resistance holds the compression of this single.

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