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RESEARCH ARTICLE

OPTIMISING THE FORMULATION OF CONCRETES USED IN RESIDENTIAL BUILDINGS IN CHAD

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Abstract

This study focuses on optimising the formulation of concrete used in residential buildings in Chad. Knowledge of the characteristics of materials through various laboratory tests, i.e. determination of the different characteristics of aggregates and cements, verification of the purity of the mixing water, and quality control of concretes, is of particular importance for compliance with the standard. Subsequently, this knowledge must be combined with the appropriate concrete formulation method: on the one hand, the Dreux-Gorisse method, which emphasizes the balance between concrete strength and workability, and on the other, the B. Scramtaiev method, which gives accurate results and seems to be the least well-known. The synthesis of all the analyses carried out in the course of this study can lead us to the kind of proposals for improvement that we consider useful and effective in the context of technical construction studies.It is in this context that our work is set, through experimental evaluation of the influence of cement dosage and type, E/C ratio, G/S ratio and aggregate cleanliness and grading, maximum aggregate diameter on compressive strength. The results obtained encourage new perspectives in the continuity of this work.The main objective of our work is to make a contribution to optimizing the formulation of concrete in the context of valorization of local materials, with the use of additives, in order to ensure adequate improvement of concrete characteristics.

Introduction:-

Concrete is a widely used building material, for both economic and technical reasons. It is made up of fine aggregates (sand) and coarse aggregates (gravel), water and cement, and the various constituents of concrete have varying degrees of influence on its properties.

A number of studies have looked at the influence of these constituents on the behaviour of concrete. For example, the influence of cement dosages or the compressive strength of concrete increases with increasing dosage [1]. A 10% increase in cement will give a 5% increase in strength [20]. Cement strength class One of the essential qualities to look for in a concrete is its mechanical compressive strength, and several studies show the evolution of the compressive strength of concretes as a function of cement class [1, 8, 18].

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The W/C ratio has a very strong influence on compressive strength: the lower the W/C ratio, the greater the increase in strength [9 and 19]. A reduction of 15 litres (per m3) in the quantity of mixing water leads to a 5 to 10% increase in compressive strength [2].

The characteristics of aggregates have a major influence on those of concrete. For example, the gravel/sand ratio (G/S) is an indicator that directly influences concrete formulation [7 and 21].

The influence of the maximum size (Dmax) of the aggregate on the compressive strength of concrete. Increasing the maximum overall diameter has a negative impact on compressive strength and the risk of blocking also increases, while reducing the size of large aggregates contributes significantly to improving workability [5, 6, 23].

Aggregate impurities can interfere with cement hydration or lead to aggregate/paste adhesion defects which impact on concrete strength [3].

Methodology:-

Sampling method and choice of locations and samples

Samples were taken by hand using small equipment (spades, picks and bags),

a) - Locality 1/N'Djamena ;

b) - Locality 3/ Abéché, 800 km from N'Djamena

Once the locations had been chosen on the basis of the abundance of materials found in these quarries, and their reputation as "exploitation quarries" for the Chad area. The samples were identified. The samples were placed in bags and transported to the laboratory with great care, then stored in a safe, dry place. We made eighteen test specimens for the town of N'Djamena, including twelve for the compression tests and six for the tensile tests (splitting). For the town of Abéché, we made twelve test specimens, including nine for the compression test and three for the split tensile test.

Identification And Preparation Of Materials

Cement

The cement used is a composite portland cement CPJ - CEMII/A class 42.5 MPa (Dangoté) and that of SONACIM class 32.5 MPa from the Baoré cement works. According to the technical data sheet drawn up by the cement plant's laboratory, this cement is composed of : (95% clinker, 5% gypsum) The characteristics of the cements used are given in tables 1 and 2.

Chemical and mineralogical analysis

Chemical analysis of the cement shows that it complies with standard NF P 15-301. The potential mineralogical composition of the cement is calculated using Bogue's empirical formula [4].

Table 1:- Chemical analysis of cement (%).

Element	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3
CPJ 42,5	20.81	4.23	5.52	62.37	2.40	2.34
CPJ 32.5	19.75	5.45	4.16	59.85	2.56	2.19

Table 2:- Mineralogical composition of cement.

Cement	C_3S	C_2S	C_3A	C_4AF
CPJ 42,5	60	15	2	17
CPJ 32.5	51	18	7	13

Physical properties of cements

CPJ-CEMII/A 42.5

Apparent density = 1030 kg/m^3

Absolute density = 3050 kg/m^3

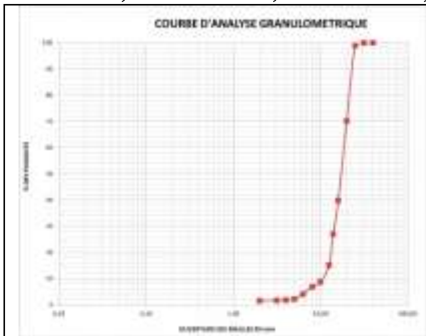
BLAINE specific surface = 4700 cm^2/g

CPJ-CEMII/A 32.5
Apparent density = 1000 kg/m^3
Absolute density = 3050 kg/m^3
BLAINE specific surface = 3700 cm²/g

Water
The water used is drinking water: its quality complies with the requirements of standard NF P 18-404.

Aggregates
In this study, we chose sand from the Chari river and crushed stone from the Dandi quarries with different fractions (5/25, 4/20), followed by aggregates collected (rolled) in the town of Abéché with a fraction of 5/25. The particle size curves are shown in figure 1.)

The particle size curves are shown in Figure 1. All properties were measured in accordance with standards NF P 18-553 - 555, NF P 18-560, NF P 18-573, NF P 18-597-598 [11, 12, 13, 14, 15, 16].

		
Grading curve for Dandy red gravel (5/25)	Grading curve for Hadjerlamis gravel (4/20)	Grading curve for Abéché collection gravel (5/25)

Results and Discussion:-

Mechanical strength
The concretes were subjected to compression tests on (16x32) cm² cylindrical specimens, each series comprising three samples [10].

Influence of cement dosage
The results shown in Figure 2 demonstrate the variation in compressive strength at 7, 14 and 28 days as a function of cement dosage. For example: the compressive strength increases at 14 days by 7% from 300 kg/m^3 to 350 kg/m^3 and 10% from 250 kg/m^3 to 300 kg/m^3. This can be explained by the fact that the quantity of hydrates formed is greater in the (300 - 350) kg/m^3 range [7].

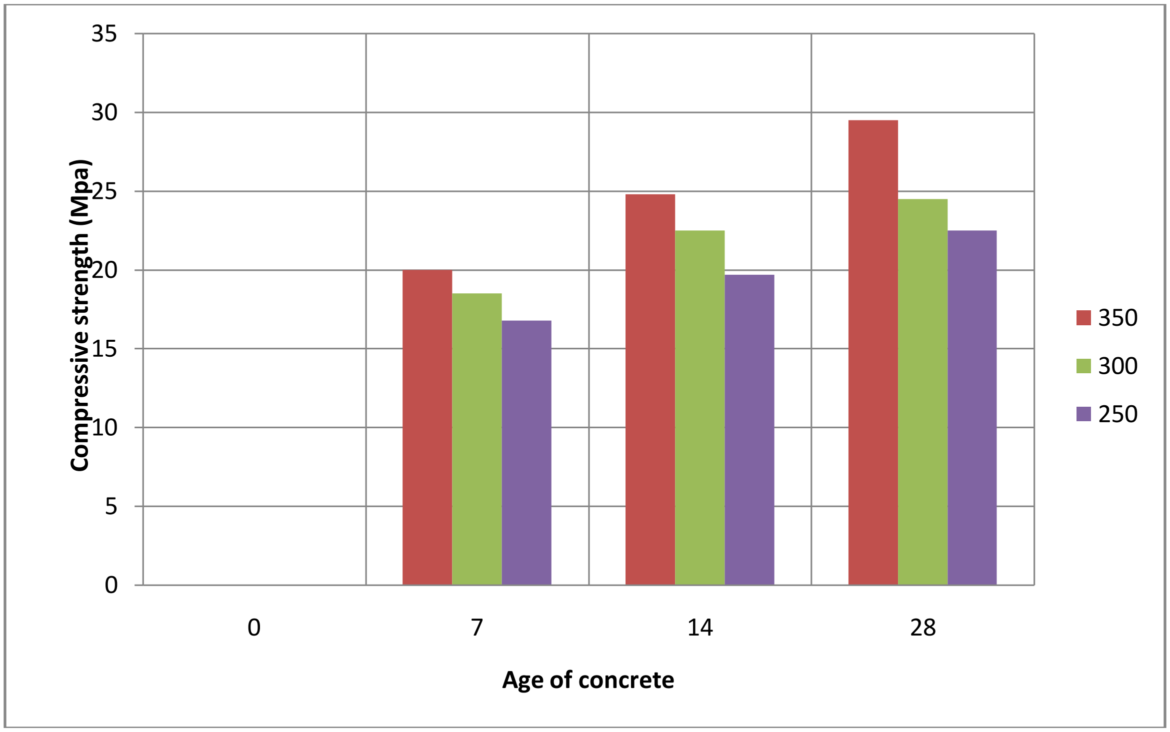


Figure 2:- Changes in cement strength as a function of dosage.

Influence of strength class

Figure 3 shows that the compressive strength of both classes of cement increases as the cement dosage increases, especially in the short term, and that the compressive strength of CPJ-42.5 develops uniformly and more rapidly than that of concrete with CPJ-32.5, especially at a young age. This is due to the microstructure of the concrete, which is formed more efficiently at a slower rate of hydration [18].

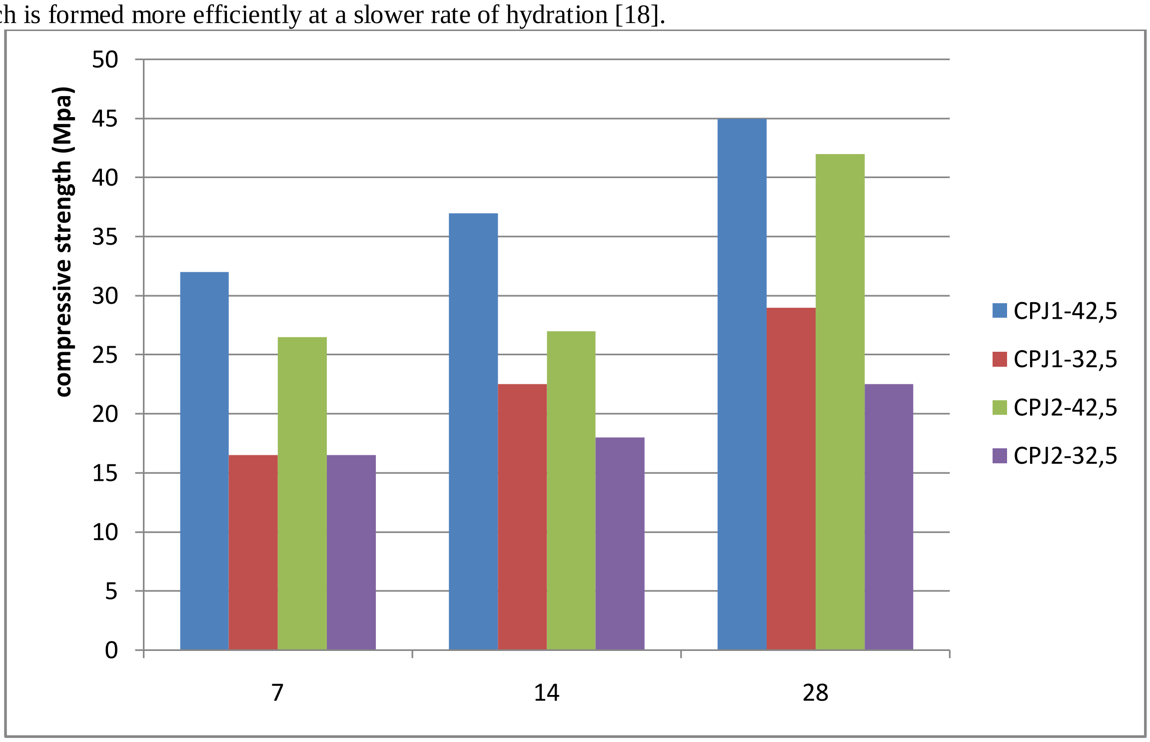


Figure 3:- Influence of concrete strength as a function of cement class.

Influence of the W/C ratio

The results presented in Figure 4 show that the compressive strength at 7, 14 and 28 days is a decreasing function of the W/C ratio. Compressive strength decreases at 28 days by 17% when the W/C ratio is increased from 0.5 to 0.55. The decrease in strength as a function of increasing W/C ratio is essentially due to a lack of formation of hydrated calcium silicate (C-S-H), which plays the greatest part in the development of strength [9].

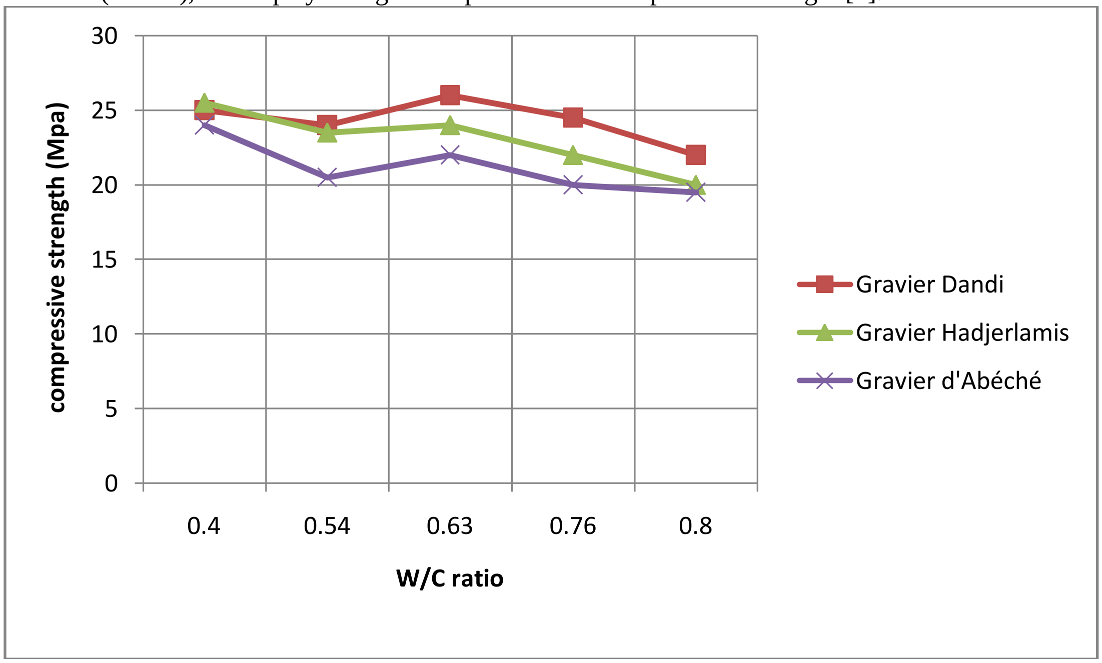


Figure 4:- Evolution of the compressive strength of concrete as a function of the different granulates studied with cement expenditure (350 $^{kg/m3}$).

The influence of the G/S ratio on concrete strength

Figure 5 shows that compressive strength increases as the G/S ratio increases. Compressive strength increases as a function of the gravel/sand ratio (G/S), and the best strength is obtained with G/S = 2.5. Compressive strength increases at 28 days by 10.5% from G/S = 1.67 to 2 and by 5.5% from G/S = 2 to 2.5 for a concrete prepared with C= 350 $^{kg/m3}$, E/C = 0.5 with a CPJ-42.5. This phenomenon is essentially due to the presence of a large quantity of gravel, which gives the concrete remarkable strength [22].

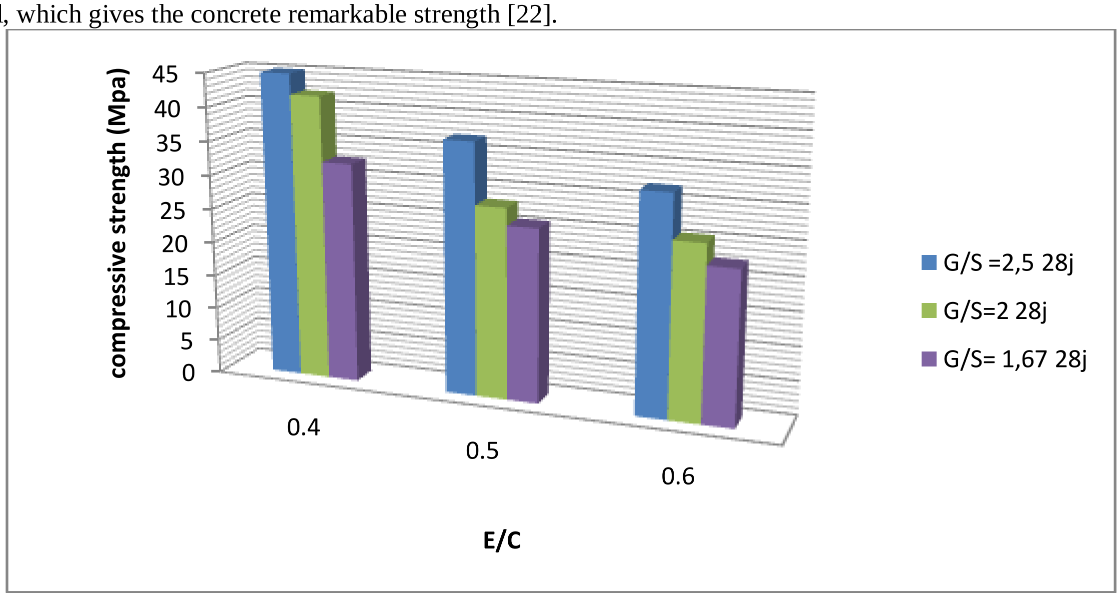


Figure 5:- Relationship between mechanical compressive strength as a function of the G/S, E/C ratio for a dosage of 350 kg/m^3.

The influence of aggregate cleanliness

The results shown in figure 6 show that the compressive strength of concrete with clean (washed) aggregates is higher than that of concrete with unwashed aggregates. This is due to the presence of fine elements and their sticking to the surface of the gravel, which can prevent good adhesion [3].

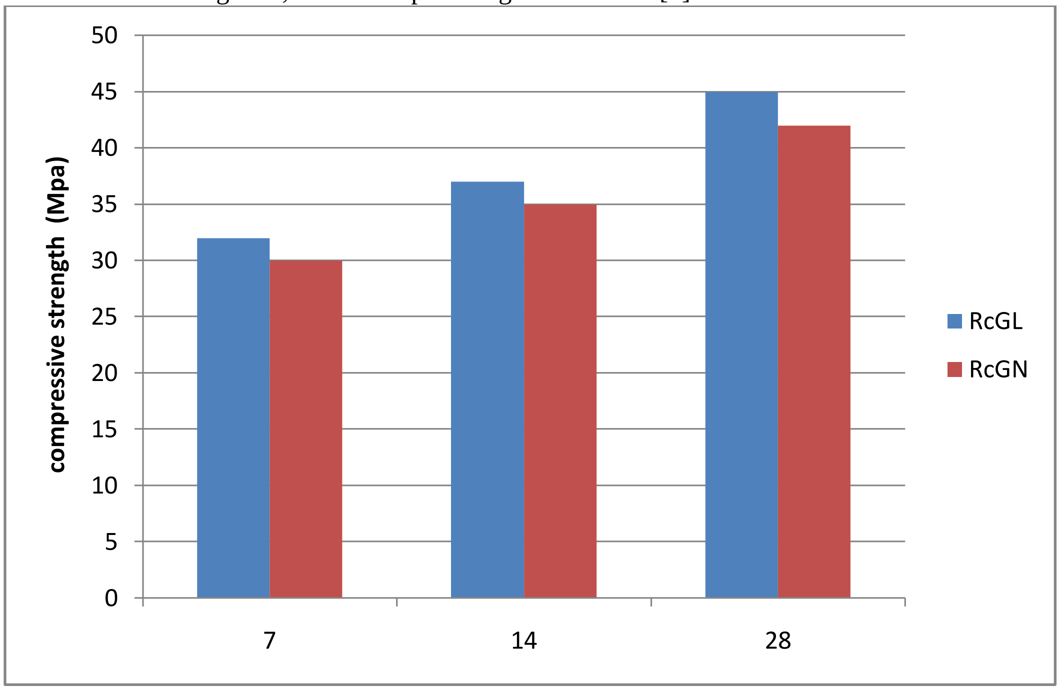


Figure 6:- Compressive strength of concrete as a function of aggregate cleanliness (E/C = 0.5 and C=350kg

The influence of maximum aggregate size

Figure 7 shows that the maximum aggregate size has an influence on the mechanical behaviour of concrete. Figure 7 shows that concrete with two granular fractions of Dmax = 15mm (5/10, 10/15) offers good resistance to co-compression than concrete with two fractions of Dmax = 25mm (10/15, 15/25) and three fractions of Dmax = 25mm (5/10, 10/15, 15/25). This is due to the increase in the sum of the specific surface areas of the aggregate grains used. The maximum aggregate size therefore has a negative impact on compressive strength [23].

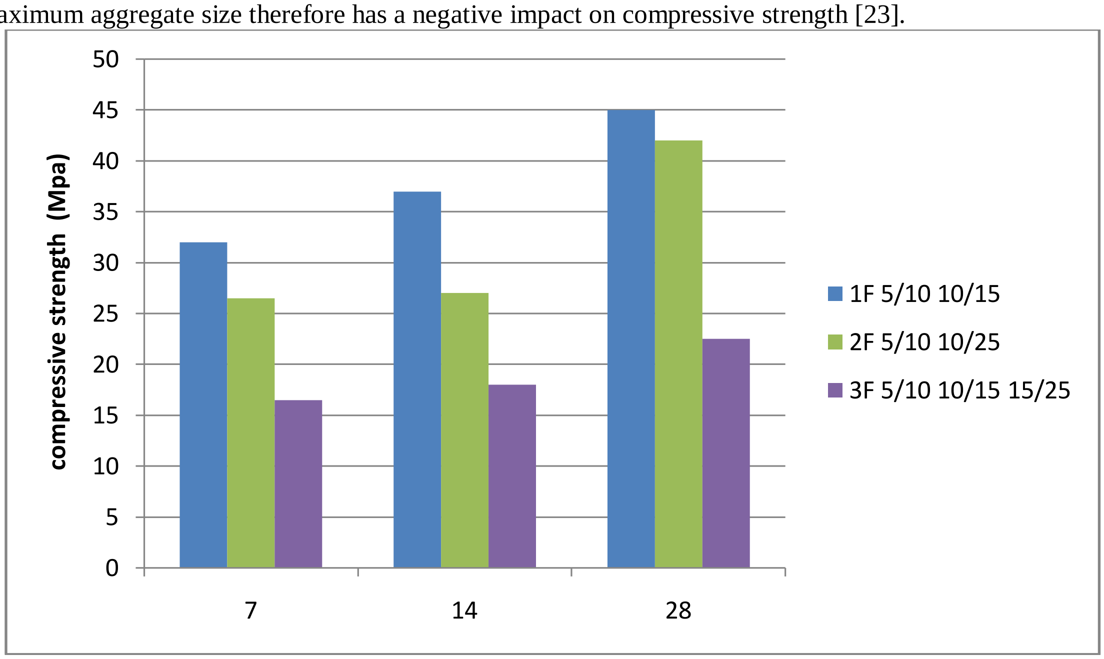


Figure 7:- Compressive strength of concrete as a function of grain size and curing time.

Conclusion:-

The main objective of our work was to study the influence of the composition parameters of a concrete based on local materials from different aggregate quarries in Chad on its compressive strength.

This set of tests confirmed a number of results reported in the literature and led to other conclusions:

- Compressive strength is an increasing function of cement dosage for both classes of cement.
- Compressive strength is a decreasing function of the E/C ratio. This decrease is more significant with an E/C ratio of 0.5 to 0.6.
- Compressive strength increases proportionally with the G/S ratio.
- The best compressive strength is obtained with G/S = 2.5. So the presence of a large quantity of gravel gives concrete remarkable resistance.
- The maximum diameter of the aggregates has a negative effect on the quality of the concrete. Concrete with Dmax = 16mm offers better resistance than concrete with Dmax = 25mm.
- The cleanliness of the aggregates has an influence on the strength of the concrete; better compression is obtained with clean aggregates.

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