

## Geotechnical valorisation of large recycling concrete in Fez-Meknes region (Morocco)

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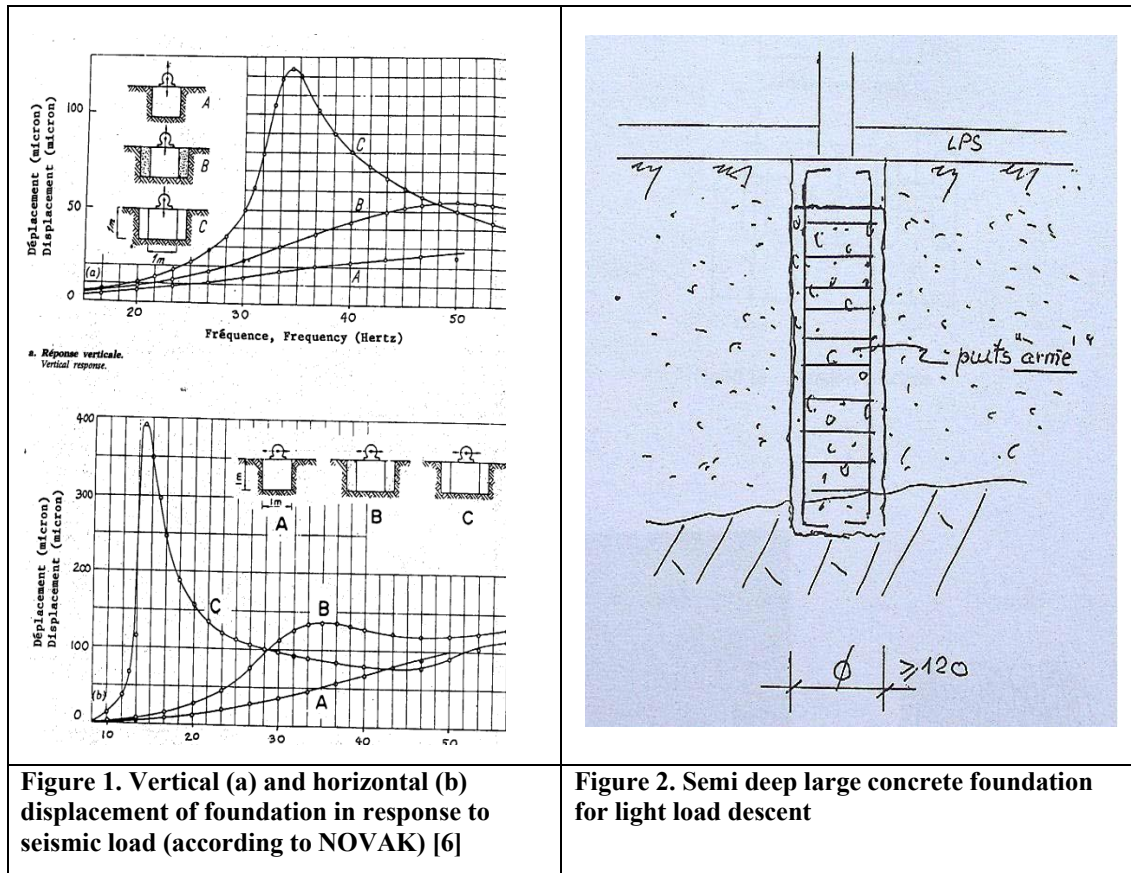
**Abstract.** The growing and accelerated development of agglomerations is resulting in increasing pressure on deposits of materials as natural resources. This results in shortages of aggregates including sand. Situation in the different regions of Morocco, including that of Fez-Meknes. In addition, the threat to the stability or durability of buildings in general and road works and their annexes in particular is often started either from the surface of the grounds or from areas vulnerable to their geotechnical contact as seating materials surrounding them. The large concrete with recycles aggregates filling or protective mask provides adequate solutions. According to the results of our research, it offers a well-adapted physical and mechanical characterization in transition between conventional concretes, whether or not they are armed, and their support. Its use of protection against the effects of erosion or scouring and against the seismic movements further strengthens its potential field employment.

### 1. Introduction

Today, more than half of the world's 7 billion people live in urban areas, particularly cities. Current trends indicate that the same will be true by 2050 for two-thirds of the world's population. This sustained urbanization is marked by the insufficiency of the natural resources of which those called mineral in answer to the needs of constructions for the urban development [1]. Ecologists by a parallelism between urban systems and ecological systems conclude that an urban metabolism shows a strong dependence on flows of building materials [2,3,4]. This translates into the strong pressure it has on the environment to absorb construction waste or construction demolition according to their age. To better fit into a circular economy, it is necessary to develop more sustainable modes and cycles of consumption of resources. We are therefore invited to use an approach of approach by multiple uses. From this angle we seek to promote the use of recycled aggregates material through better scientific and technical knowledge. The latter obtained from the standard conventional concrete construction will be incorporated to obtain large enough resistant concrete. Among the multiple uses that we propose:

- Firstly, the confinement of the grounds [5] or embankments envelops of the foundations of construction, in particular against the seismic risk as shown by Figure 1.
- Secondly, the transition of catching of the level of sitting on support ground of better bearing, exceeding those of surfaces sensitive to swelling-withdrawal or collapsible (Figure 2).
- Thirdly, intermediate seating of structures, obstruction of karst or anthropic cavities [7] and reinforcement of various urban water networks, to mitigate or stop leaching phenomena by erosion.





**Figure 1. Vertical (a) and horizontal (b) displacement of foundation in response to seismic load (according to NOVAK) [6]**

**Figure 2. Semi deep large concrete foundation for light load descent**

## 2. Research Methodology

### 2.1. Presentation of the approach and context

Related to Taza region, Morocco, our investigations were carried out according to the following steps:

- The contextual analysis of the use of mineral resources, sands and gravels, as well as the concretes that they compose. This directs us towards the source aggregates of calcareous origin or wadi for the sand.
- The destination analysis of a concrete based on its interaction with the soil or embankment envelops, in particular, the transition interfaces. This latter makes use of the strength or compactness of the large concrete product.
- The development of a practical approach for a better optimization of use by recycling materials from demolition concretes or waste from construction sites.

### 2.2. Type of large concrete envisaged

#### 2.2.1. Natural aggregates sources

The aggregates used in the parent-concrete formulation are derived from the middle Atlas limestone quarries, more precisely Sefrou quarries [8,9] and the wadi sand as an alternative.

#### 2.2.2. Definition of Big Concrete

Large concrete is a concrete usually dosed between 150 and 250 kg of cement with an increase in the amount and maximum diameter of pebbles and decrease in the amount of sand. The large targeted concrete is soft and homogeneous, which allows it to substantially fill the cavities at the walls of the foundation well digs manually or shovel.

### 3. Material and method of experimentation

In order to make the large concrete object of our research we have been careful to control its genesis as highlighted by the phases of our experiments. The natural aggregates of the city of Sefrou are the base of the concrete of the laboratory cylinders. This parent concrete is in turn considered as "artificial rock" for obtaining recycled bass. In parallel this rigor is accompanied by a simulation of concrete crushing by a heavy compactor site. Two different formulations are made. In the first sand comes from recycling. Whereas in the second it comes from wadi.

#### 3.1. Storage of parent concrete cylinders

More than one hundred cylinders of source concrete have been selected and stored (Figure 3). They carry the same components of formulations "aggregates, sand, cement, water." according to the standard of concrete NF EN 206 [9]. Their quality is identified by tests of density, compressive strength and traction. These characteristics are: a density of 2,4-a compressive strength at 7 days of age between 16 and 21 MPa for 21 and 27 Mpa at 28 days. While the one with traction at 28 days is between 1.8 and 2.7 MPa.



Figure 3. Cylinder of parent concrete after compression failure



Figure 4. Raw recycled concrete gravels



Figure 5. Selected recycled gravel

#### 3.2. Crushing.

The particle size desired by the crushing spread from 0.1 to 40 mm in diameter using the steam roller (Figures 4 and 5).

##### 3.2.1. Wheel crushing

The advantage of this grinding is the obtaining of a grain size of crude enough coarse.

##### 3.2.2. Cylinder crushing

The product of the under-roller passes of the compactor made it possible to recover a crushed crude of granulometry rich enough in fine.

#### 3.3. Identification tests

Concrete aggregates from cylinder crushing are sorted, crushed and sieved. The physical characteristics determined in the laboratory are presented in the tables below.

**Table 1.**Physical characteristics of recycled aggregates (chippings and pebbles)

Characteristics of chippings and pebbles Averages	Medium
Natural water content w (%)	2.36
Actual density (g/cm <sup>3</sup> )	2.32
Real density imbibed (g/cm <sup>3</sup> )	2.48
Bulk density (g/cm <sup>3</sup> )	1.33
Atterberg limits wl, wp et Ip(%)	Atterberg limits

**Table 2.**Physical Characteristics of Recycled and Wadi Sand

Characteristics of sands	Medium	
	Recycled sands	Wadi sands
Natural moisture content w (%)	9.12	4.1
Actual density $\rho_r$ (g/cm <sup>3</sup> )	2.01	2.62
Real density imbibed (g/cm <sup>3</sup> )	2.26	2.66
Apparent density (g/cm <sup>3</sup> )	--	1.5
Atterberg limits wl, wp et Ip (%)	Not measurable	Not measurable

The curve of the granular mixture is as follows (Figure 6).

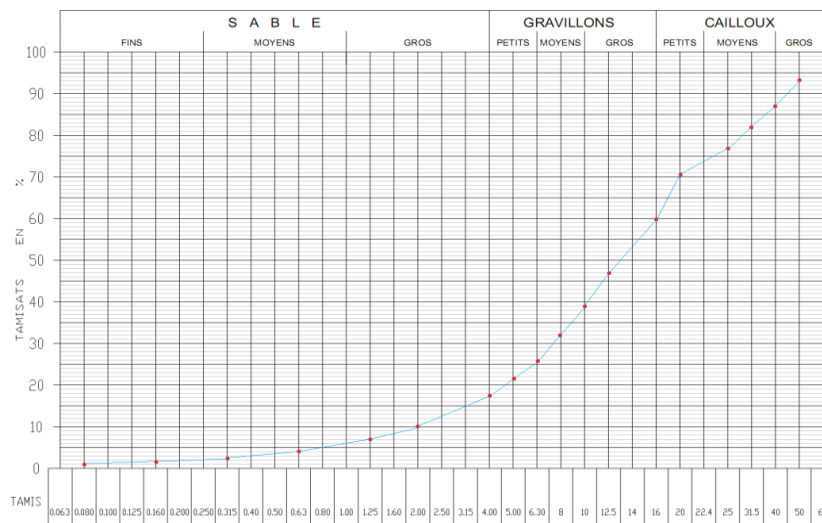


Figure 6. Particle size analysis of the mixture of recycled gravel

The Los Angeles "LA" fragmentation resistance of recycled aggregates is 29% according to the standard NM 10.1.138 [10] reference of the European standard NF EN 12620 [11]. It defines a maximum value "LA" of 30 for a good concrete of current construction.

### 3.4. Formulations of the large Concrete

The formulation of the large concrete is composed according to the abacuses of the usual concretes [12,13].

#### 3.4.1. Dosage and quality of the cement

The simplified method has been used to determine the quantity of cement required in kg per m<sup>3</sup> of fresh concrete used. The dosages are guided by the approximate resistance targeted for the concrete. The cement is of Portland type compound CEM II 32.5 with an absolute minimum resistance of 30 MPa at 28 days according to the European standard NF EN 197-1 [14]. It is well adapted to our type of big concrete.

#### 3.4.2. Determination of aggregates and water

The granular composition is approximated in volume for the manufacture of the experimental cylinders [15]. The entries of the following charts take into account the initial humidity of the recycled aggregates and the handling of the large fresh concrete (Figure 7).

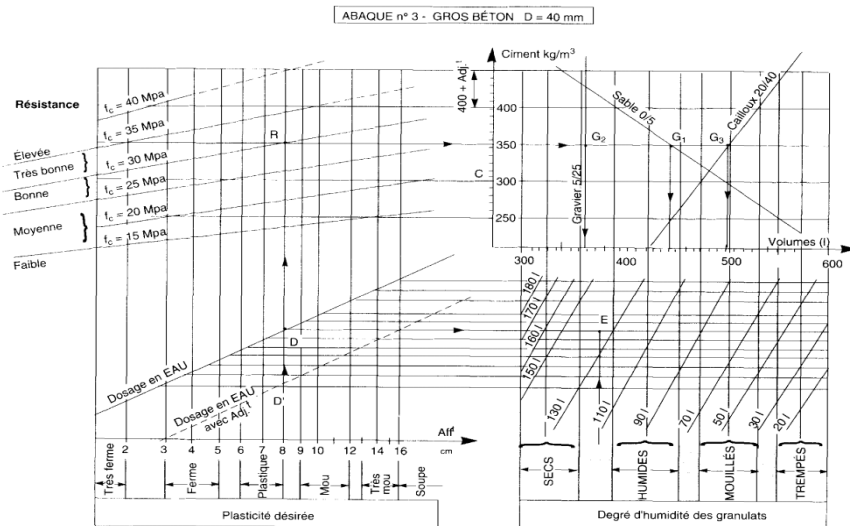


Figure 7. About assays of concrete components according to simplified method[12]

### 3.5. Practical application of the proposed simplified method

#### 3.5.1. Formulation of 100% recycled aggregates

For our formulation of large concrete only recycled aggregates are retained initially: sands and gravel from our crushing to which we have added the quantities of cement and water predetermined. During this composition as for the following we have targeted a cone plasticity sag of 10 cm for a better manoeuvrability on the one hand, and a resistance of 5 Mpa to 28 days on the other hand.

#### 3.5.2. Formulation of the big concrete with recycled gravel and wadi sand

For the second formulation we substituted the sand of wadi sand recycling by sieving the bass to 6mm. The sieve serves us for sand corrections useful to the first formulation of all recycled.

## 4. Results and discussion

### 4.1. Basic data

The large concrete made from recycled aggregates is intended for filling to improve the hydro-geotechnical context. A maximum dimension of the aggregates of 40-50 mm. A manoeuvrability of 10 cm is very convenient. The dosage cement is guided by a resistance of  $f_{c28d} = 5\text{MPa}$ .

### 4.2. Simple compressive strength of concrete with 100% recycled aggregates (Figure 8)

The test consists in imposing, between two plates of a press, a constant speed of longitudinal deformation of each specimen in large concrete of 16 cm of diameter and 32 cm of height. (Figure9). The results obtained are shown in Table 3.





Figure 8. Cylinders of 100% recycled large concrete



Figure 9. Compression test of large concrete cylinders

#### 4.3. Dynamic auscultation tests by propagation of sound velocity (Figure 10)

The standard measurement [16] of the velocity of sound is read across each large concrete specimen before it is crushed. This test reflects the internal structure thanks to the longitudinal waves of compression (P waves).

The device is composed of the sound propagation device connected to an oscilloscope acting as an electro-acoustic transducer

The results are summarized in Table 3 below.

Table 3: Resistance to compression results and corresponding sonic velocity at 28 days

Large concrete with 100% recycled aggregates			Large concrete with added wadi sand		
RC7d (Mpa)	RC28d	Speed (Km/s)	RC7d (Mpa)	RC28d	Speed (Km/s)
9,5	9,5	4,08	<b>8,5</b>	<b>10,5</b>	3,57
16	<b>12,5</b>	4,17	8,5	12,0	3,78
<b>11</b>	13,0	<b>4,13</b>	9,0	10,0	<b>3,75</b>

We note that the compressive strength of recycled concrete is nearly half that of parent concrete. In parallel its density is of the order of 2.2 lower than 2.4 parent concrete. This confirms greater porosity for the first in comparison.



Figure 10. Ultrasonic apparatus

We also find that the values of the resistance of the large concrete are higher with the addition of the recycled sand than with the wadi sand. The median value of the resistance to 7 days of age for the first one is superior to the median value of the second at 28 days. The same trend is verified by sonic velocities performed at 28 days. We can retain a minimum resistance of 10 MPa.

Moreover, the homogeneity of the large concrete, as shown by its granulometric curve of the dry mix (Figure 6), reinforces the protection of soils and embankments of the foundation or containment against the erosive effect due to possible runoff in the absence of the large concrete.

## 5. Conclusions

The experiments carried out on the large concrete based on aggregates from recycled concrete can lead to a sufficiently rigid and waterproof material. It meets the needs of continuity in gradual transition interface to the support of the structures.

This type of recycling will largely contribute to the recovery of large concretes in general and in particular in the region of Fez-Meknes which is experiencing exploitation pressures of the aggregates leaving the risks of their scarcity to hover. The discharge of the concrete discharges will be reduced.

Areas of research can be developed from the need for reinforcement, protection or consolidation necessary for the stability and durability of the works with respect to geotechnical hazards or vulnerabilities. For our part, we have indicated certain uses favourable to the improvement of the soils of erosion protection and limitation of the amplitudes of seismic actions.

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