WPI3.3.2. Site specific report on extraction activities performed, pre-processing of bulk samples, raw materials extraction (led by CTP) -including elements to feed the database needed to design the SMARTIX (WPT2) and for the performance report (WPT3)

Antoine Masse, Philippe Descamps, Laurent Dumortier

Centre Terre et Pierre

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1.Introduction

On the La Louvière Duferco site, tree different slag streams have been identified. They consist in electric arc furnace slag, basic oxygen furnace[1] slag and ladle slag. Amongst those streams, the first and the second have found applications in road construction whereas the last one is not valorised yet mainly due to the risk of swelling associated with the presence of magnesium oxide. It is precisely this ladle slag which must be landfilled due to a lack of technical solutions that has been selected for the pilot test.

In a previous stage of the project, this ladle slag has been treated at small pilot scale in CTP starting from material sampled in different areas of the La Louvière site (c.f. report D. T.2.1.2). The flowsheet of the treatment applied in CTP and the results of the matter recovered at each of the different operations is shown at Figure 1. As expected the metal scraps recovered are very low whatever the area of sampling (S2, S6 and S8) and the main mineral fraction to be valorised consists in 10-30 mm aggregates and a fine fraction minder than 10 mm.

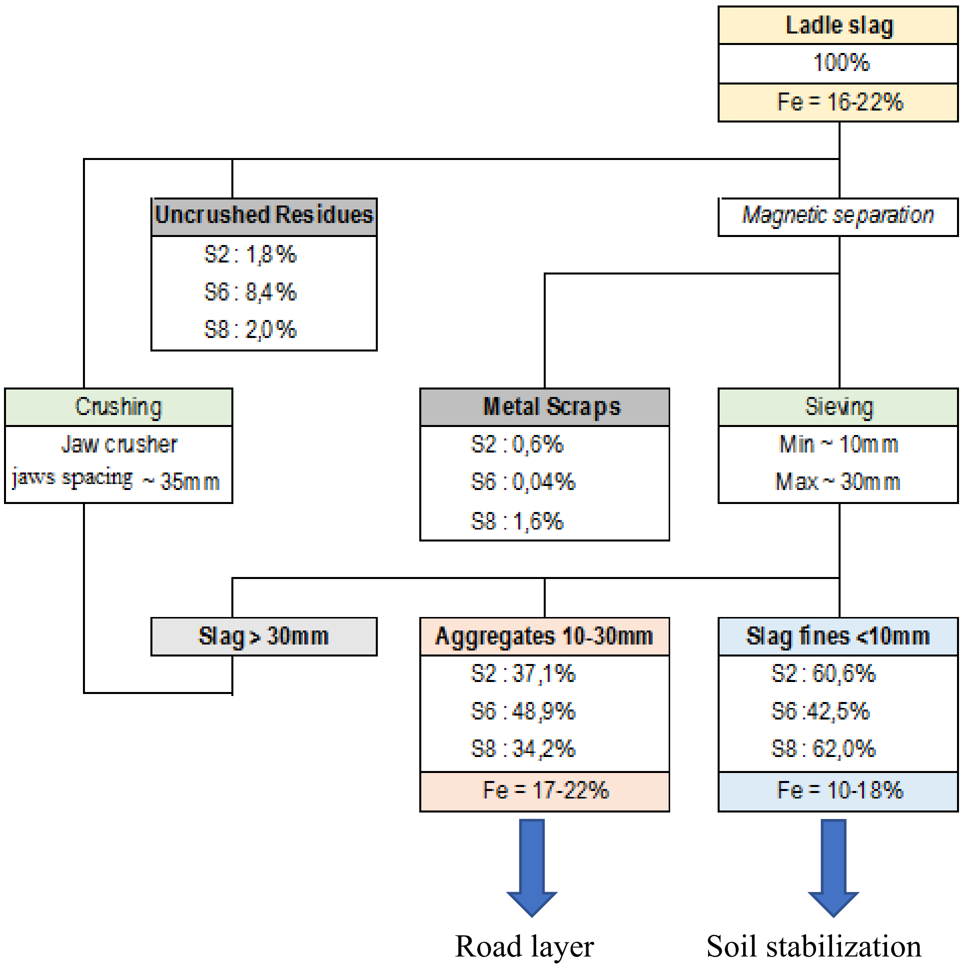

Figure 1 : Flowsheet of the slag sample processed in CTP

[1] LD converter

Laboratory scale state have also demonstrated that, thanks to an additional treatment aiming to improve its reactivity, the fine slag fraction can be used for wet soil stabilization whereas the coarser fraction 10-30 mm can be foreseen for road subbase, road subgrade or embankment depending of their bearing capacity once compacted (Figure 2).

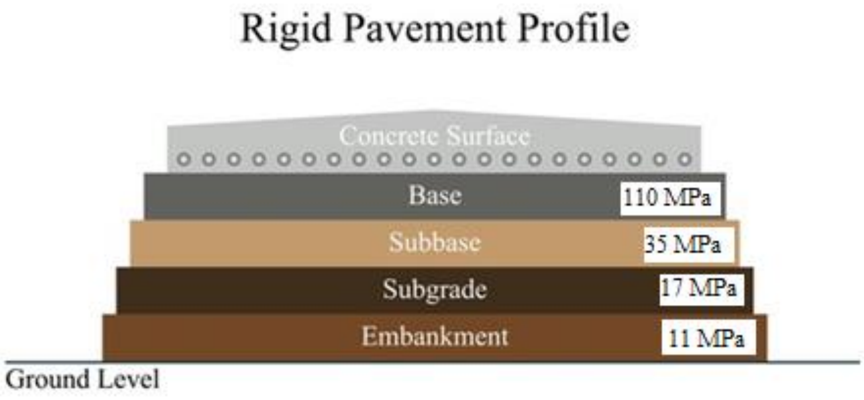

Figure 2: Minimal bearing capacity values for a use in road construction in Wallonia (according to “Qualiroutes” criteria)

Based on those very promising results it has been decided to go ahead and to treat larger quantities of ladle slag on La Louvière site using industrial equipment in order to :

- assess if the ratio of the different recovered fractions is the same as for the small pilot test performed at CTP
- have enough materials for implementing large scale test slabs acting as demonstrators on the same host site.

2. On site processing of ladle slag

2.1. Description of the process flowsheet

Around 3050 tonnes have been treated on site according to the mineral processing techniques. For an easier understanding, the global flowsheet of the applied treatment has been shared in different parts.

Prior to the treatment, large heterogeneous materials as those shown on Picture 1 (216 tonnes) have been removed. Then, the mineral matter has been sieved at 32[2] mm using a double deck screen (Picture 2) in order to obtain two fractions: one smaller than 32 mm and another larger than this cut size value. This first stage of the treatment is illustrated in the following Figure (Figure 2).

[2] The sieve mesh was slightly different from that used for the pilot tests at CTP (30mm), as sieves allowing to make a size cut at 30 mm were not available at that time.

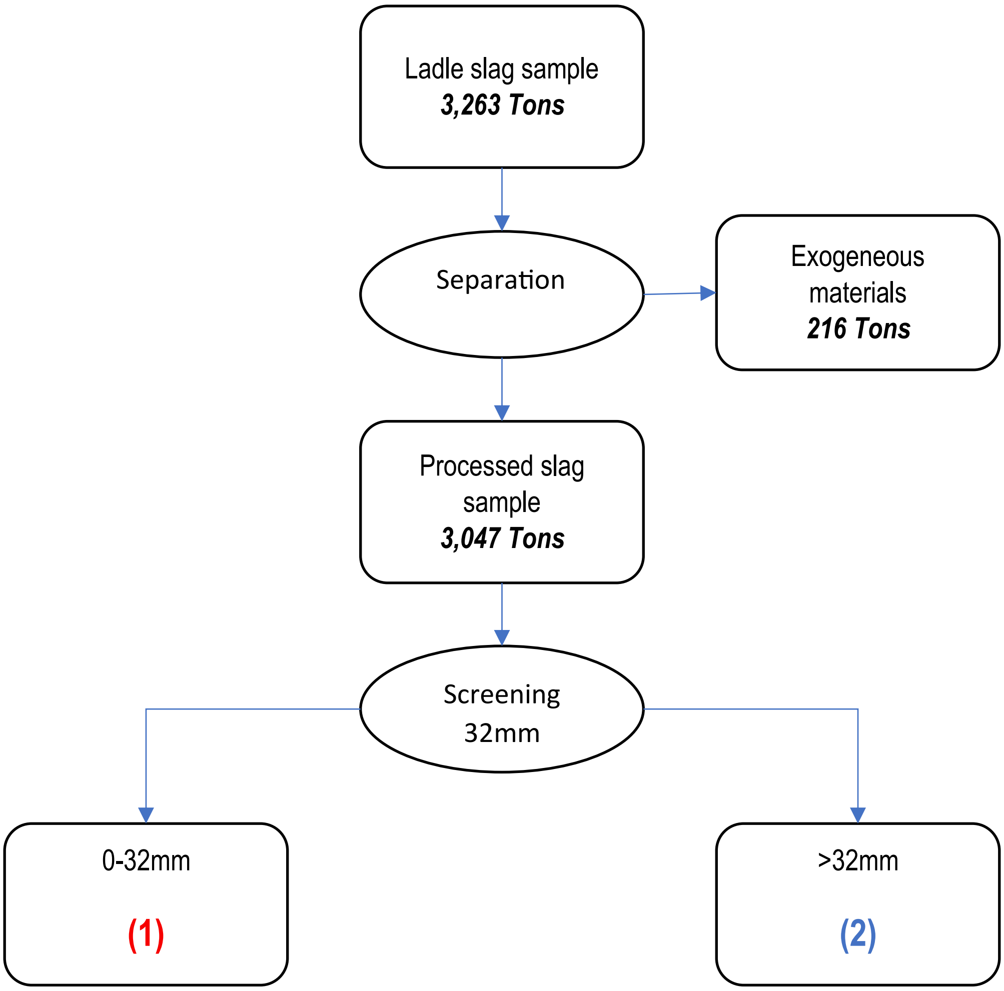

Figure 2: Process flowsheet - production of 0/32 mm and > 32 mm slag fractions

Picture 1: Large heterogeneous materials

Picture 2: Double deck screen

Figure 2: Process flowsheet - 1rst stage

The second stage consists in treating the fraction below 32 mm **(1)** in order to produce three different fractions. As can been seen from Figure 3 examination, after a preliminary removal of metal scraps using an overband, the finest fraction (10mm) is separated by using a trommel screen (Picture 3) and the 10 mm oversize is further sieved thanks to a 3-deck screen (Picture 4) allowing to produce three different fractions : a 0-10 mm fraction which is mixed with the one issued from trommel screening, an intermediary 10-20 mm fraction and a coarser fraction with particles ranging between 20 and 32 mm.

Picture 3: Screening trommel

Picture 4: 3-deck screen

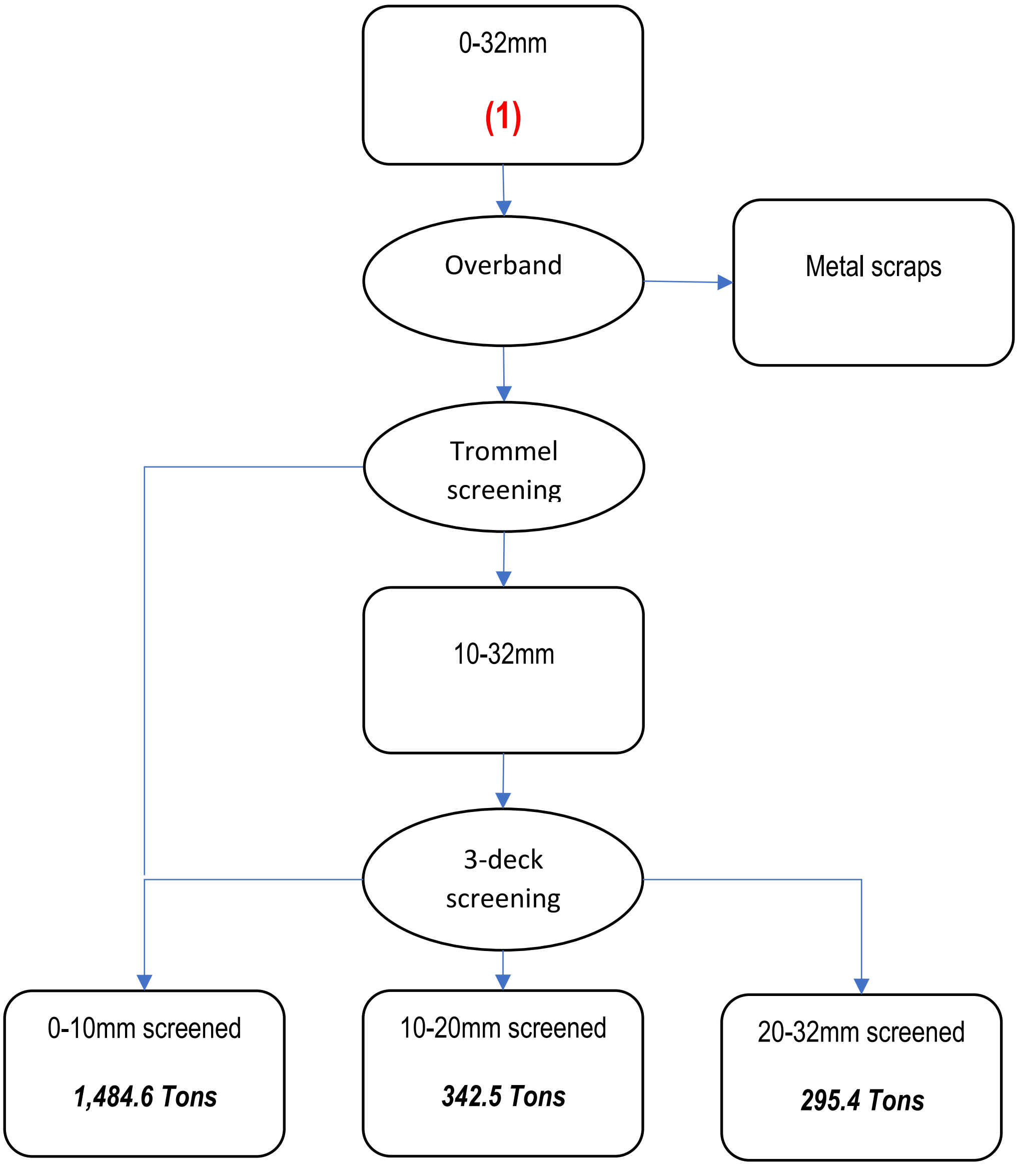

Figure 3: Process flowsheet – Treatment of the sieved 0/32 mm fraction in order to produce three sub-fractions: 0/10 mm, 10-20 mm and 20/32 mm

The third stage consists in processing the coarser slag fraction **(2)** in view both of reducing its metal scraps content and of decreasing its particles size below 32 mm **(3)** as shown in Figure 4. For this purpose the slag fraction > 32 mm was spread on the ground and the remaining metal scraps recovered using a circular lifting electromagnet (Picture 5) which in the same time allows to avoid damaging of the crusher in the next step. Indeed, once depleted in metal, the coarse slag is introduced in a jaw crusher (Picture 6) to proceed to a grain size reduction. The ground slag is then sieved at 32 mm and the oversize is returned to the jaw crusher feed to close the loop.

Picture 5: Circular lifting electromagnet

Picture 6: Jaw crusher

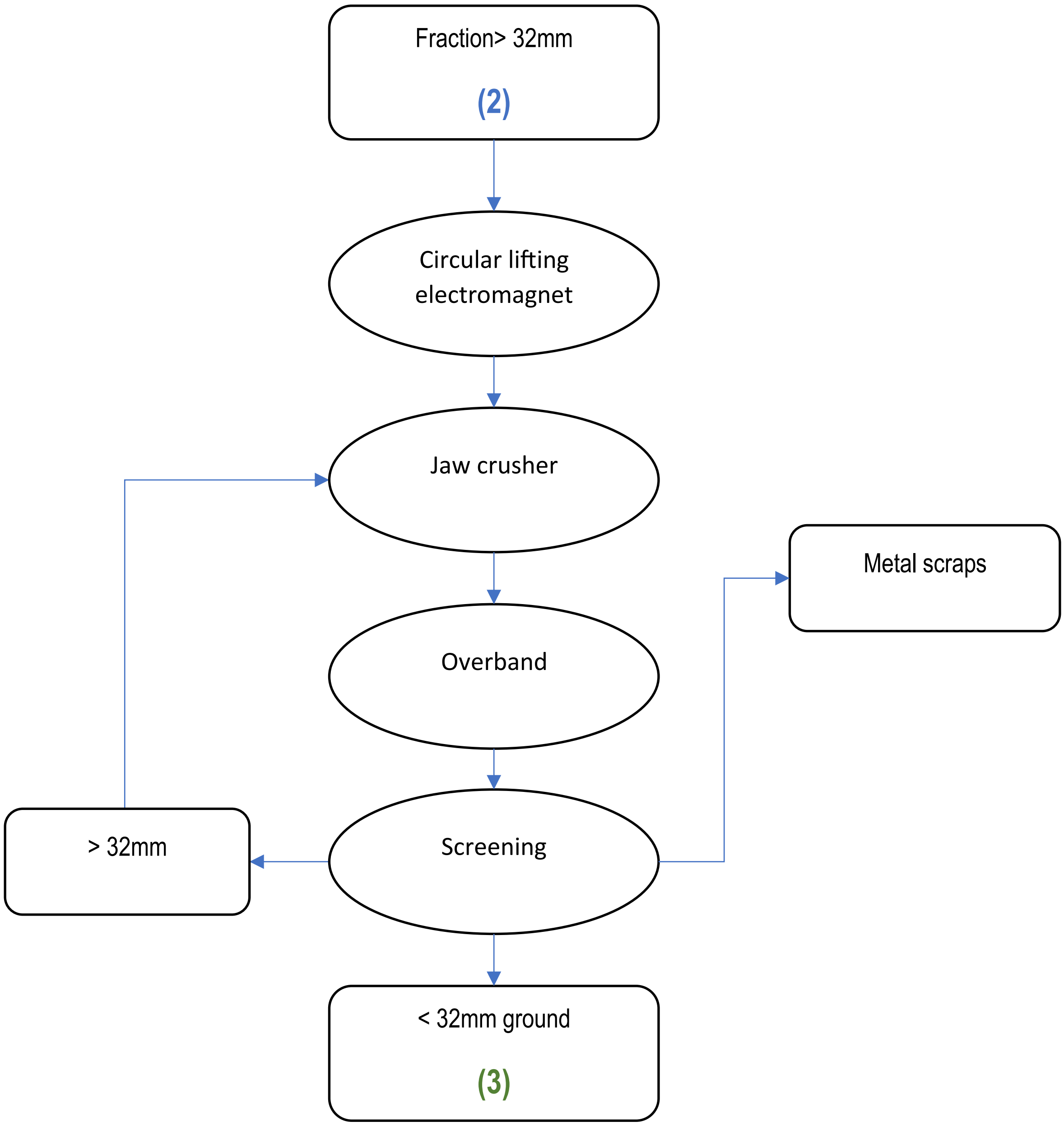

Figure 4: Process flowsheet – treatment of the sieved fraction > 32 mm to reduce its grain size below 32 mm

This 0-32 mm slag fraction is then subjected to an additional treatment (Figure 5) very similar to the one adopted for the unground slag having the same particles size range and which is illustrated in Figure 3.

Indeed, the 0-10 mm fraction of the ground 0-32 mm fraction is first separated by sieving using the trommel screen. Afterwards the 10 mm oversize, i.e., the 10-32 mm fraction, is sieved using the 3-deck screen in order to produce the same three fractions: 0-10 mm ground, 10-20 mm ground and 20-32 mm ground. As previously, the finest 0-10 mm fraction is mixed with the one issued from trommel screening and covered with a waterproof tarpaulin.

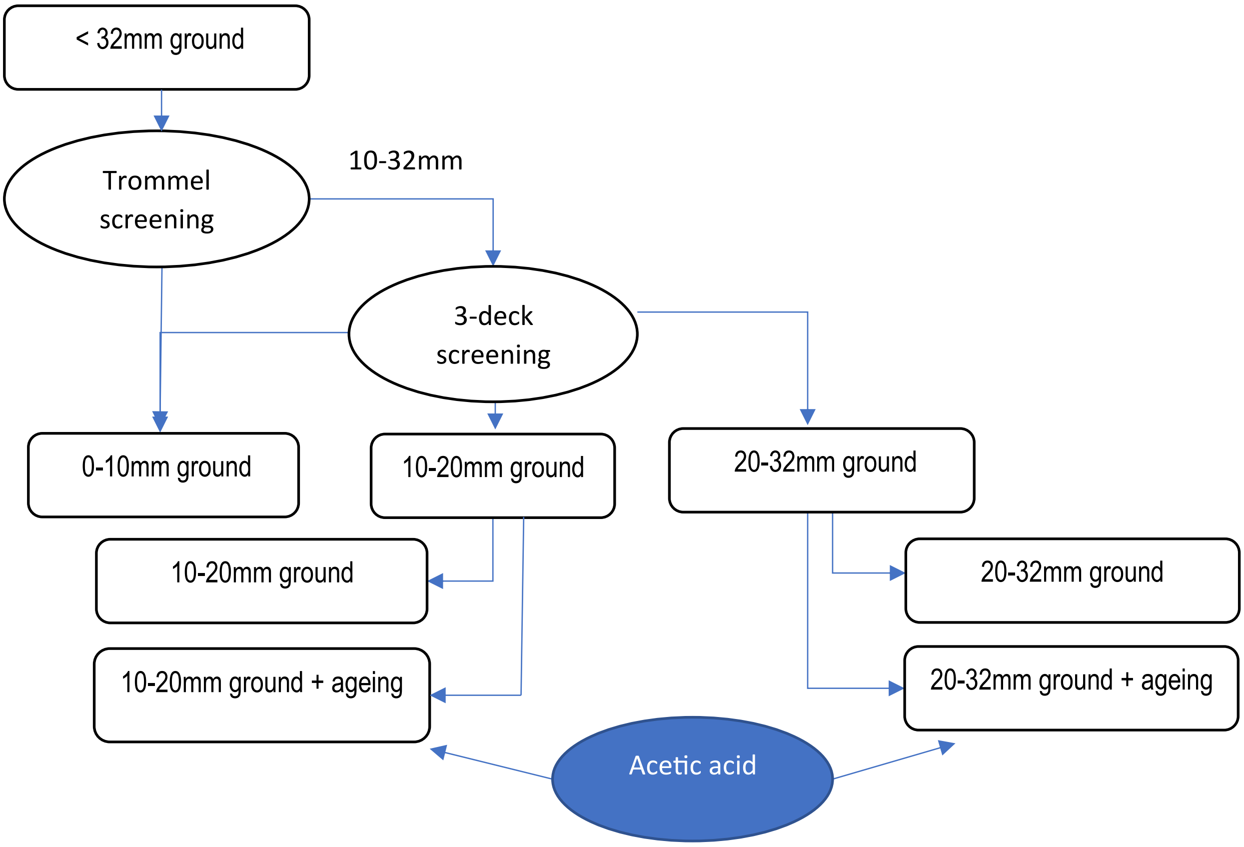

Figure 5 : Process flowsheet - Treatment of the ground 0/32 mm fraction in order to produce three sub-fractions: 0/10 mm, 10-20 mm and 20/32 mm

It must be pointed out that grinding leads to the release of magnesia particles, whose delayed hydration can lead to a deleterious swelling phenomenon for the coarser fractions. For this reason, an accelerated ageing step was applied to these fractions before the test slabs were set up.

For this accelerated ageing step, acetic acid was added at a rate of 50 l/tonne (Picture 7) as, according to the literature (Figure 6), this is likely the most effective reagent. The corresponding chemical reactions are listed below.

$$CH_3COO^- + MgO\,(s) + 2H_2O \rightarrow CH_3COOMg^+\,(aq) + 2OH^-$$

(Dissolution of magnesia in acetic acid)

$$CH_3COOMg^+\,(aq) \rightarrow CH_3COO^-\,(aq) + Mg^{2+}$$

(Dissociation of the magnesium complex)

$$Mg^{2+} + 2OH^- \rightarrow Mg(OH)_2 \searrow$$

(Precipitation of magnesium hydroxide by supersaturation)

Picture 7: Equipment used to spray acetic acid reagent

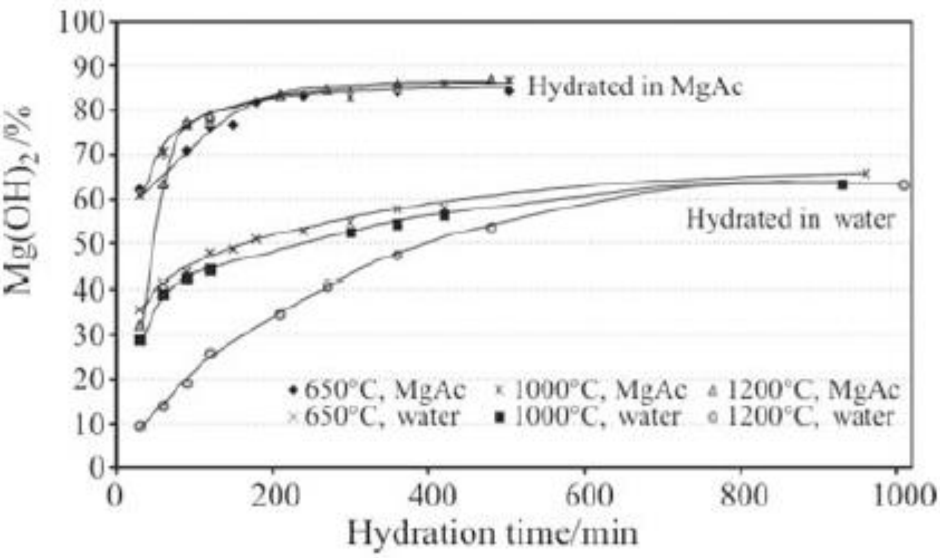

Figure 6 : Effect of acetate ions addition on the hydration rate of MgO

The visual aspect of the different fractions which can be potentially reused are shown in the following Pictures (8 to 10)

Picture 8: Metal scraps

(a) 0/10 mm (b) 10/20 mm (c) 20/32 mm

Picture 9 : Slag fractions obtained by sieving

(a) 0/10 mm (b) 10/20 mm (c) 20/32 mm

Picture 10 : Ground slag fractions

2.2. Mass balance resulting from mineral processing

The mass balance resulting from the mineral processing applied to the ladle slag is reported in table 1. Except the lost matter resulting from on-site slag processing (243 tons), the fractions which clearly cannot be valorised consists in the large heterogeneous parts, the non-crushable materials, the sludge and the coarser fraction resulting from the crusher adjustment which corresponds to less than 15 % of the processed slag. Thus, the remaining fractions can be potentially foreseen for applications in soil stabilization (fines) or in road construction (aggregates). It must be pointed out that concerning the ground 10/10 and 20/32 mm fractions, only the amount necessary to implement the test slabs on site has been treated with acetic acid. However, for possible further valorisation those fractions will have to be submitted as a whole to an accelerated ageing in order to ensure that no swelling phenomenon may occur.

Matter type	Mass (tons)
Total amount of slag	3263
Large heterogeneous materials removed prior mineral processing	216
Processed slag	**3047**
Fe metal scraps	57.69
Screened 0/10 mm fraction	1484.60
Screened 10/20 mm fraction	342.50
Screened 20/32 mm fraction	295.40
Ground 0/10 mm fraction	198.50
Ground 10/20 mm fraction without accelerated ageing	27.80
Ground 20/32 mm fraction without accelerated ageing	54.30
Ground 10/20 mm fraction with accelerated ageing	28.30
Ground 20/32 mm fraction with accelerated ageing	54.60
Non-crushable materials	32.80
Sludge	34.20
32/56 mm fraction (crusher adjustment)	192.90
Matter lost on the ground	243
Chemical reagent	Amount (liters)
Acetic acid	4145

Table 1 : Mass balance

2.3. Global recovery diagram

The global matter recovery diagram of the slag processed on site is illustrated in Figure 7. This diagram also shows the quantities corresponding to each fraction. Conversely to expected, bearing tests performed on La Louvière site have proved that, like the ground 0/10 mm fraction, the screened 0/10 mm fraction also display a certain reactivity and could presumably be used for soil stabilization in addition to other valorisation routes (for instance, use in cement plant as raw material for clinkerization). Keeping this in mind, except the lost material resulting from the treatment, the heterogeneous large parts removed before starting mineral processing and the sludge, both the metal scraps (1.87%) and the fine and aggregates slag fractions (81.5%) can be valorised. **This corresponds to a mass of more than 2500 tons which is well above the target value of the project (800 tons)**. When compared with the results obtained at small pilot scale in the CTP, it is clear that the finest fraction (0/10 mm) remains the major one. The main difference lies in the metal content, which is higher when the tests are carried out on site, likely due to the presence of very large metal parts scattered throughout the slag heap.

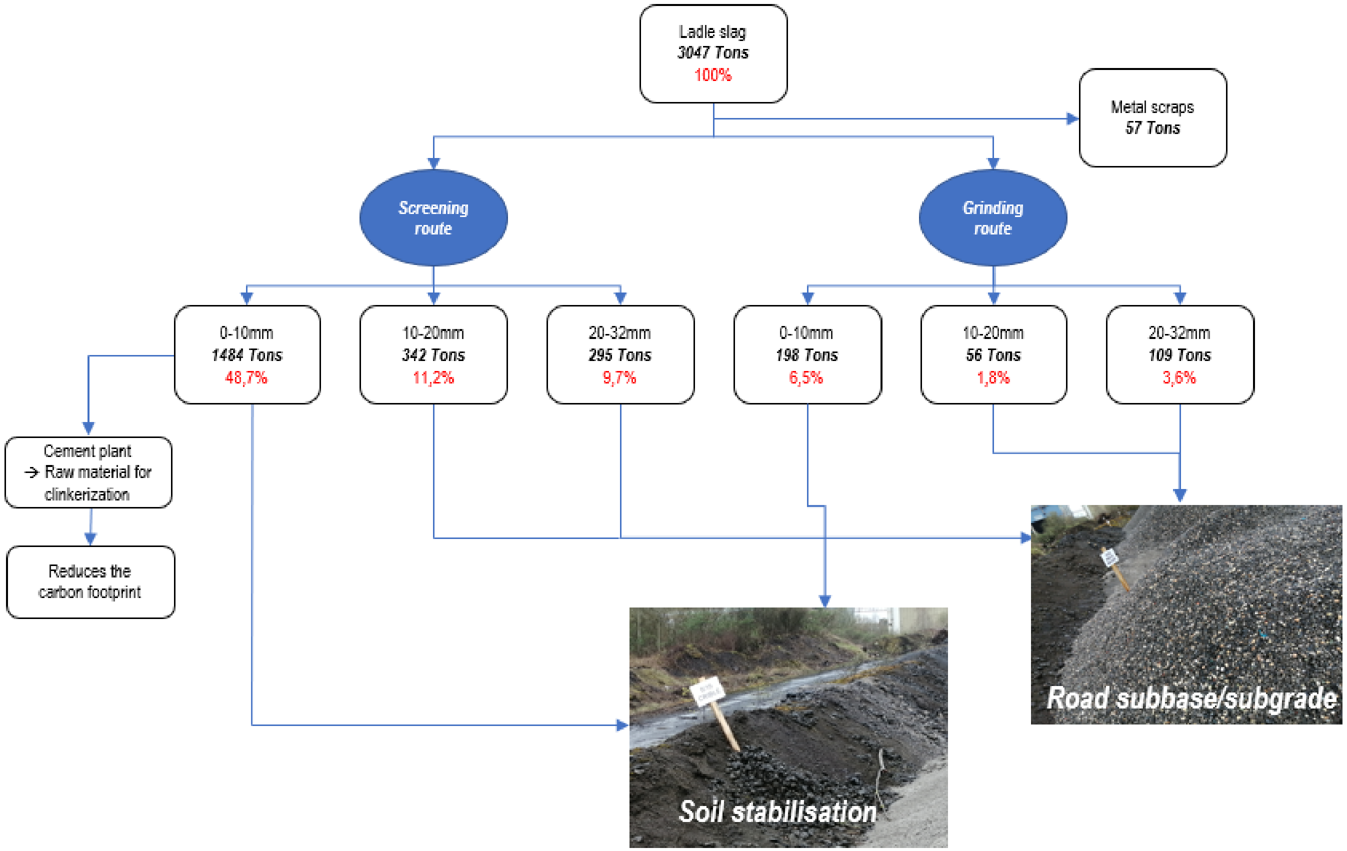

Figure 7: Global matter recovery resulting from on-site slag processing

1. Conclusions

Based on the results of mineral processing performed in CTP, on the bearing capacity of soil stabilized with the 0/10 mm fraction measured according to IBI[3] method and on the characteristics of the aggregates fraction (10/30 mm) both in terms of grain size distribution, abrasive wear, shock resistance, frost resistance and swelling, it has been jointly decided to treat the slag (around 3000 tons) on a large scale on La Louvière site. The purpose was to assess if the ratio of the different recovered fractions is the same as for test performed at CTP but also to have enough materials for implementing large scale test slabs acting as demonstrators on the same host site.

Thus different test slabs consisting in stabilized soils and compacted slag aggregates have been implemented on La Louvière site. The plate bearing tests carried on each of the test slabs (see report I3.4.3) proved that:

- a loamy soil stabilized with the fine 0/10 mm slag fraction can be used as road subbase and that whatever its treatment (either sieving or grinding + sieving);
- Compacted aggregates, in spite of their lower bearing capacity, can nevertheless be used as road subgrade.

As a consequence, in addition to the metal scraps, a large part of the mineral fraction of the slag (2484 tons which corresponds to 81.5% of the 3047 tons processed slag) can be valorised which is well above the target value of the project (800 tons).

[3] IBI : Immediate Bearing Index