RE-USING RECYCLED MATERIALS FOR THE CONSTRUCTION OF AIRPORT INFRASTRUCTURES

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In its 2006 strategic areas for development, Aéroports de Paris committed to the sustainable development principle. This commitment is based on better management of its existing and future assets, in particular by means of a HEQ approach (High Environmental Quality) for recently launched operations such as the T2G terminal. Re-use and saving of materials in infrastructure work sites, which has been going on for several years, is an integral part of this choice. This is a solution for the situation in the Ile-de-France region: low aggregate resources, with a very high demand for construction materials.

At the same time, the COLAS group and its subsidiaries, SCREG Ile-de-France Normandie, COLAS Ile-de-France NORMANDIE, COSSON and JOUEN, which play a big part in the installation of infrastructures and maintenance at the Aéroports de Paris platforms, have for several years been making runways, aircraft parking areas and taxiways and carrying out numerous maintenance jobs (aircraft maintenance agreement and road system at the Orly platform executed by SCREG Ile de France Normandie for over 30 years) re-using demolition materials.

This does not mean that airport infrastructure work need not satisfy highly strict specifications and standards in terms of their constituent materials. So it was not a matter of taking risks in terms of the function and durability over time of these materials. The progress has been slow but each stage, each work site and each recycled material needs to be validated for the sake of durability and safety.

The article below retraces 5 years of use and progressive re-use of recycled materials in work carried out by SCREG Ile-de-France Normandie – Colas Ile-de-France Normandie and COSSON for Aéroports de Paris at the Roissy Charles de Gaulle, Orly and Le BOURGET platforms

1. RUNWAY 4 ORLY - 2006

Aéroports de Paris assigned the COLAS group to carry out the reinforcement work on runway 4 and improvement work on the West of the ORLY platform (France's number two airport platform) required among other reasons for the arrival of the Boeing 777 – 300 ER, which generates a high load transfer in its ground movements.

The contracts make a total of around 26 million Euros, with 2 separate lots.

1 / Lot B consists of laying the concrete pavements and their foundations for a runway apron and a few taxiways. Firstly the existing infrastructures were demolished, and then new structures were installed. Over a period of less than 8 weeks, the work for this lot was conducted as per the stages below:

DEMOLITION OF CONCRETE PAVEMENT OVER 35,000 M².

To speed up the job, the demolition was carried out using COSSON's slab crushing machine. This K3B type crushing machine consists of 3 drop hammers each weighing 3500 kg. The demolition operation for taxiways W 41, W 47 and 48 had an execution procedure aiming to provide a precise definition of the energy required to crush the slabs. The drop height of the hammers and the drop gap were determined on test beds. Once this "crushing" job was complete, hydraulic shovels removed the concrete fragments formed. *These concrete fragments* were then stacked on a specially prepared platform so as to avoid contaminating their quality. The work done by the crushing machine made it possible to reduce the size of the fragments and minimise re-crushing with a hydraulic rock breaker (HRB).

[figure 1: COSSON's crushing machine]

[figure 2: COSSON's crushing machine] [figure 3: COSSON's crushing machine]

CONCRETE CRUSHING

A mobile, KLEEMANN REINER type, COSSON crushing unit was running at full speed, 16 hours per day with two crews, and a daily production of up to 3000 tonnes. The entire COSSON materials service was mobilised for this exceptional site, where the schedules were very tight (and therefore the penalties for delay high: € 40,000 per day)
The 0/600 blocks were loaded onto a vibrating table feeder by a hydraulic shovel. (See figure 4)

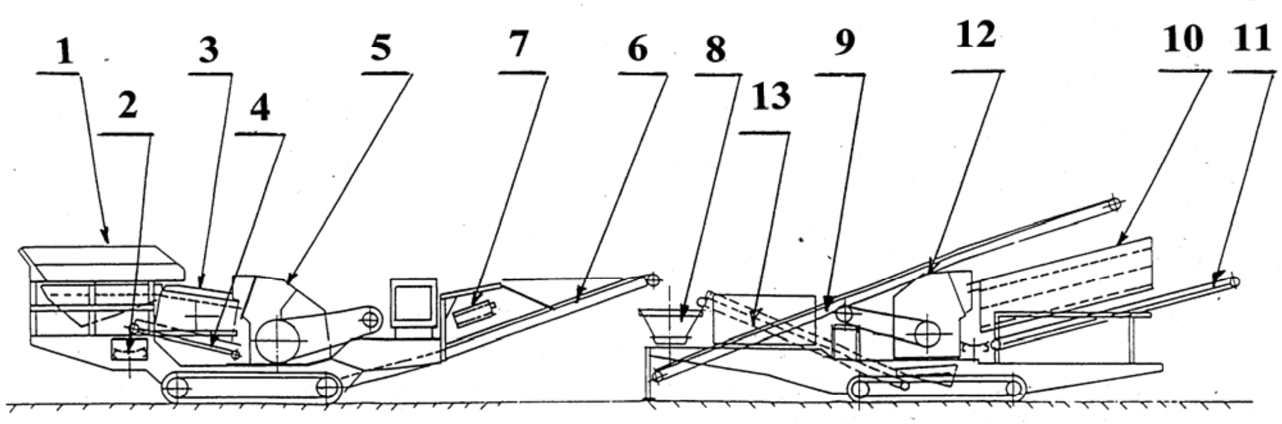
A scalper (2) sorted these materials so as to only pass the 31.5/D fraction to the primary impact crusher (3). The waste 0/31.5 materials were piled up by a conveyor belt (after weighing).

The 0/150 mm materials from the primary crusher went through metal extraction (7) at the outlet of the primary crusher (5) and were forwarded to the secondary impact crushing unit (12).
The 0/60 mm materials from secondary crushing went through metal extraction (9) and were carried by conveyor belt to the screening unit (10).
The 0/31.5 mm fraction went directly to storage after weighing on the conveyor
The materials produced were stacked by a wheel type loader.

The fraction greater than 35 mm (from screening) was reintroduced into the secondary circuit.
Some of the bigger fraction was then simply screened to produce a grading 30/80material.
This material was to be used over the 2200 metres of cut-off drains

1 – Hopper 2- Scalper 3 – Conveyor belt 4- Extractor 5 – Crusher 6 – Transfer belt	7 – Overband 8 – Hopper 9 – Conveyor belt 10 – Screen 11- extractor 12 – Crusher 13 - Conveyor

Convoyeur à bande 13 - Convoyeur
Crible
extracteur
Concasseur



PRIMARY SECONDARY

[figure 4: crusher]

The quality of the crushed concrete was ensured by external and outside inspections on-site.
For a production of 40,000 tonnes of crushed concrete, the contractual Quality assurance plan stipulated the following tests to be conducted:

- 55 grading and water content analyses for validation as per the range in standard [1].
- 6 crushed concrete mechanical characterisation tests as per the Los Angeles and MDE standards [2].
- 55 material property characterisation tests by means of the blue mass test [3].
- 55 sulphate content determination tests as per standard [4].

Through cleanliness of material, very low sulphate contents, high mechanical performance levels, uniformity of grading curves and controlled water content, crushing of the runway concrete thereby produced a material achieving the highest crushed concrete category – category GR4 – as per "the Technical guide for using Ile-de-France regional materials" [5].

The performance levels of these crushed concretes enabled usage as a capping layer under new taxiways for a weight of 40,000 tonnes, but also as major constituent of graded aggregate bound with cementitious binders for the sub-bases under the shoulders of runway 4, and as a drainage/filtering capping layer for cut-off drains.

For this lot, nearly 40,000 tonnes of crushed concrete was directly re-used on the site. Without this re-use, we would have needed to remove this volume of material to an off-site storage platform and supply the site with 40,000 tonnes of materials required to make the layers mentioned above. In view of the presence of a Filtering Inspection Unit, the time scale required for the procurement of these materials would have been a great impediment to satisfying the work schedules and obligations to reopen the taxiways and runway 4.

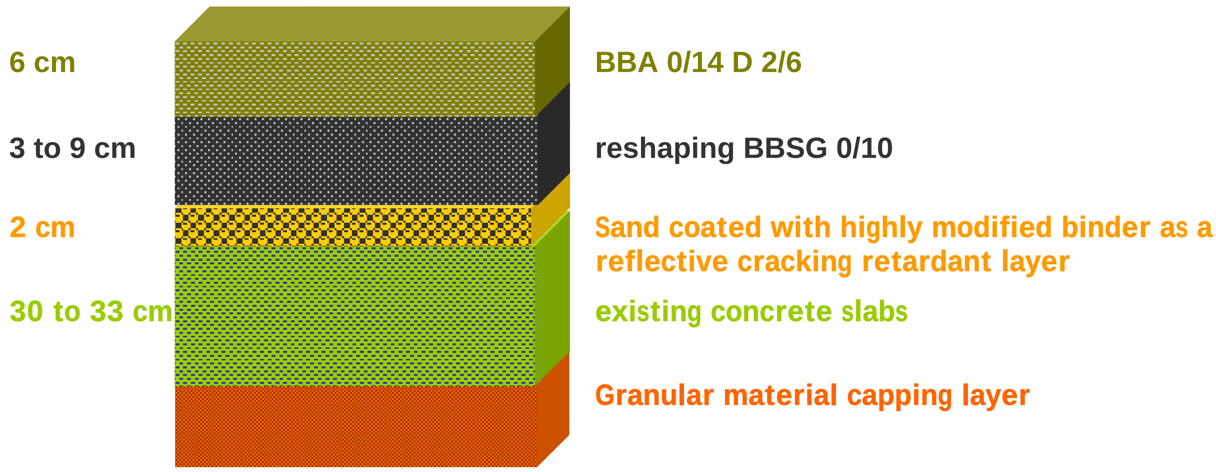
So re-using materials on-site had a direct effect on the environment, limiting the transport of materials by lorry. For this work site, that represented energy consumption savings and greenhouse gas emission savings of nearly 120 tonnes of CO_2 equivalent: and 1833 GJ of energy, i.e. equivalent to the annual consumption of 660 French households. (Calculations based on an energy bill of 2188 KWh/year/French household – data from ADEME)

2. RUNWAY 07/25 – LE BOURGET 2004 / 2005

At the end of 2004, LE BOURGET airport was preparing to receive AIRBUS' A380 jumbo jet, which would land for the first time in Ile de France at the Aeronautics Trade Show of June 2005. So Aéroports de Paris initiated two work sites on runway 07/25, 3000 m in length and 45 m wide. Their structure consisted of cement concrete slabs dating from the Second World War (30 to 33 cm thick). The shoulders, consisting of untreated graded aggregates with a variable thickness of surfacing on top, were supported on a silt base.

The first work site involved overlaying runway 07/25 with bituminous surfacing, except for the verges which remained concrete. The contract stipulated the use of a proven technique concrete slab overlaying technique validated by Aéroports de Paris.

This existing structure can be modelled as below:



To lay this structure, the SCREG/COLAS partnership proposed adding 10 % surfacing aggregates to the reshaping BBSG 0/10. Production was carried out by two fixed units at Gennevilliers in Hauts-de-Seine, with a throughput capacity of at least 650 tonnes per hour. COSSON processed and stored the 0/8 cut surfacing aggregates on these sites using an SBM type COSSON crusher

[figure 5: SBM crusher in action, crushing surfacing aggregates]

Principle: before treatment, the aggregates were prepared to reduce them to a dimension compatible with the crushing equipment. The biggest fragments were reduced in a rock breaker, which eliminated the biggest impurities.

The materials prepared were then transferred by a wheel type loader, picked up by a hydraulic shovel and inserted into the crusher feed hopper.
They then passed onto the pre-screening scalper, which sent the fraction smaller than 8 mm directly onto the conveyor for pre-screened materials.
The fraction bigger than 8 mm was sent to the impact crusher, which fragmented the blocks before sending them onto the screener feed conveyor.
The materials were then put down on the screen, which calibrated the materials to 8 mm.
At the screen base, the 35 mm fraction was extracted from the unit by finished product conveyors.
The fraction bigger than 8 mm was introduced into the crusher by the recycling conveyor until the desired grading was achieved.

At the crusher outlet after weighing the materials were piled up by a wheel type loader.

The quality of these surfacing aggregates was validated by internal and external inspections on-site.
For the 3000 tonnes of surfacing aggregates produced for the work site, the contractual Quality assurance plan stipulated the tests to be conducted. This in particular observed the specifications of standard NF P 98 135 [6], subsequently replaced by an equivalent European standard EN 13 -108 -8 [7], and went further by incorporating an external inspection plan, the rheological characterisation of the aggregate bituminous binders.

The following tests were conducted on the stock of 3000 tonnes of aggregates:

- 7 grading and water content analyses (as per standard NF EN 933-1)
- 2 rheological characterisation tests conducted on the recovered binder (say which)
- 3 binder content determination tests (as per standard NF EN 697-1).

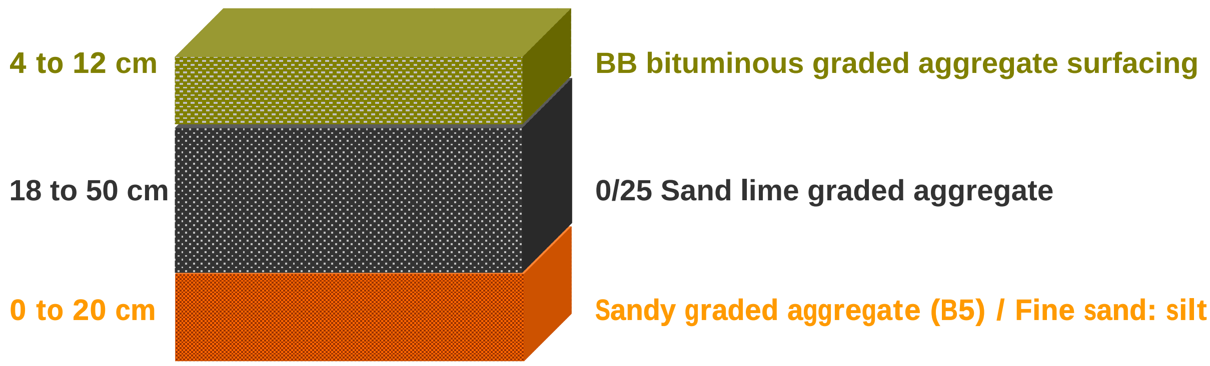
This addition of 20 % surfacing aggregates in this surfacing formulation enabled the direct addition of 1 % bitumen. For a Bituminous concrete formulation with 5.7 % bitumen, adding these surfacing aggregates therefore enabled the added bitumen to be reduced to 4.7 %. For this overlay work, this provided a saving of over 150 tonnes of bitumen, and reduced by over 1500 tonnes the addition of aggregates from a quarry nearly 300 km away from the surfacing production sites. In transport savings alone for these raw materials this meant a reduction of 450,000 MJ, i.e. the equivalent annual consumption of 163 French households. (Calculations based on an energy bill of 2188 KWh/year/French household – data from ADEME)

This practice is now widespread for reusing these materials which are no longer considered final waste, but raw materials.

The second work site undertaken by ADP on runway 07/25 for receiving the AIRBUS A 380 was relaying the shoulders. Indeed, the shoulders posed genuine risks of materials being blown away. Furthermore, the shoulders had to be able to withstand occasional passage of the landing gear of any aeroplane accidentally deviating from the runway. The constraints for carrying out this work were great. Indeed, the work for these shoulders had to be performed at night, as the runway was in service in the daytime. This operating constraint prevented leaving steps of over 6 cm for the restart of work every day.

In view of these constraints, and still within a sustainable development approach, the SCREG Ile de France Normandie / COLAS Ile de France Normandie partnership conducted numerous analyses and surveys for the purpose of accurate identification of the materials in place.
The existing shoulders consisted of type A1 silt as per GTR 92 or type B5 sandy graded aggregates as per GTR 92, untreated graded aggregates with a variable thickness of surfacing on top.

This existing structure can be modelled as below:



For these shoulders, the basic solution consisted of 35 cm of lime treated silt on 20 cm of GTLH T3 and 6 cm of BBA 0/10. This shoulder structure was developed and validated by test beds laid by STAC in TOULOUSE, using a trailer simulating the AIRBUS A 380's 2-wheel landing gear, at normal operating load.

The SCREG COLAS partnership proposed the variant of a structure incorporating planing of the surfacing and treated graded aggregate of the shoulder, followed by spot treatment over 45 cm of the mixture of silt and untreated graded aggregate. This spot treatment prevented major expenses, ensuring continuity of runway operation during the daytime, limited the transported quantities and reused the site materials. This treated material, once applied, covered with chippings, emulsion and gravel, was then covered by a 0/10 grading runway surfacing with a thickness of 6 cm.
This varying structure was verified mechanically by SCREG Ile de France Normandie's and LITP's Technical Services after modelling of the AIRBUS A 380's landing gear. Validated by Aéroports de Paris, this varying structure fitted perfectly into the operating constraints of the LE BOURGET runway.

In terms of technical inspections, in one week the LITP and SCREG Ile de France Normandie laboratories conducted 18 surveys with compete GTR characterisation of the constituent materials of the shoulders, 35 sulphate content tests, verified the suitability for soil treatment as per standard NF P 94 100 and performed a complete survey on the existing shoulders using a LACROIX deflectograph to validate the proposed technical solution.

The SCREG / COLAS partnership work crews treated the shoulders over 45,000 m² in a record time of 2 weeks. Over this short period, nearly 800 tonnes of limestone and 1800 tonnes of cementitious binders were spread and mixed using 2 x 700 HP mixers belonging to JOUEN.
In terms of mechanical performance, the results have been highly satisfactory, since the LACROIX deflectograph acceptance tests gave an average of under 30 hundredths of a millimetre at a very young age.

3. T2G

This work site located in the East of the CDG platform, which started in 2006, is to give rise in 2008 to a terminal and to new parking areas (26 places) to provide Air France with a regional communication centre, primarily within the Schengen area.

The parking areas cover an area of around 45,000 m². The structure of these parking areas is a 35 cm concrete layer, on a 30 cm foundation made from graded aggregate bound with cementitious binders, and then a silt capping layer treated with limestone and cementitious binders.

The quantity of cementitious graded aggregate to be applied is around 100,000 tonnes.

These 100,000 tonnes will be produced by COSSON via the Class 3 SAE type SORMAT plant, which has a production capacity of 600 t/h.

[figure 6: SORMAT manufacturing plant]

For this class 3 graded aggregate bound with cementitious binders as per standard NF EN 14 227-5 [8], the constituent level of crushed concrete is 45 %. This 0/20 grading concrete crushed at the COSSON platform mainly comes from concrete recycled from ROISSY Charles de Gaulle platform pavements.

To validate this recycling material and deal with any risk of a quality defect with this major constituent of the graded aggregate bound with cementitious binders, the COSSON laboratory conducts a number of tests. The frequency of these tests is drawn up in a specifications document validated by the project management with Aéroports de Paris' laboratory. These frequencies are as follows:

- Water content and grading analyses: 1/500 tonnes
- Sulphate determination: 1/ 200 tonnes
- Determination of LOS and MDE technical performances: 1 /2000 tonnes
- For the sulphate levels determined as per standard XP 18 581[4], the maximum threshold of 0.8 % is reduced as per the Guide for the use of crushed concretes in Ile-de-France. The maximum threshold is reduced to 0.5 % so as to deal with any risk of swelling. The average value obtained is 0.23 %.

4. CONCLUSION

To carry out work on the airport infrastructures, the first form of re-use was for years the near-systematic re-use, geometry and phasing permitting, of the silt materials from sites with a foundation top and capping layer. The performance levels of lime / cementitious binder treated silts from Roissy or Orly are high and durable.
For several years, the COLAS group and its subsidiaries, COLAS Ile de France Normandie, SCREG Ile de France Normandie, COSSON and JOUEN have been carrying out work and providing products within an environmental approach. For work on airport facilities, which have a high material consumption, the COLAS group systematically developed the re-use of the materials in place and recycled materials: so for cementitious graded aggregates, the level of which rose progressively from 11 % (Verge 26 work site carried out by SCREG Ile de France Normandie in 2003) to 26 % (FEDEX parking areas – production by COSSON and work site by COLAS Ile de France Normandie in 2005) and

then 45% (T2G parking areas – production by COSSON and work site by COLAS Ile de France Normandie in 2007).
Today if the source of recycled materials is very uniform and well controlled, we can apply Treated graded aggregates containing 100% crushed concrete, except for the addition of a grading corrector if necessary. (Air France complex – production by COSSON and work site by SCREG Ile de France Normandie in 2005)

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