ACTION 1 – DEVELOPMENT OF THE BARRIER COMPONENTS WITH RECYCLED MATERIALS

ACTION 1.3 Concrete with chip reports

1. DESCRIPTION

The present document aims to collate and summarise the studies conducted on the use of ELT materials as partial substitutes for conventional aggregates in concrete.

It will begin by looking at the articles and publications collated for previous studies. It will then describe the laboratory tests carried out to measure the physical and chemical characteristics of the concrete when different percentages of ELT rubber and steel fibres are added. Lastly it will analyse the technical and economic feasibility of the use of rubber-concrete in New Jersey barriers. The study will also define the percentage of rubber substitute required to meet the barrier specifications.

2. REPORTS AND DATABASES COMPILED IN PREVIOUS STUDIES

The reference literature reviewed on this subject tends to focus on the use of granulate (smaller rubber particles). The main features noted are the loss of compressive strength and lighter nature of the concretes produced.

In general, rubber-concrete exhibits better properties for small particle sizes, although the cost is considerably greater. For this reason, the study has centred on the use of larger sizes of rubber given that the use of smaller rubber particles in the concrete needs to contribute a property of some kind that justifies the cost increase. If not, the majority of companies would not be willing to accept the additional costs.

The SIGNUS study has centred on two main aspects, namely, replacing coarse aggregates by adding rubber chip to the mix with and without ELT steel fibres to produce positive results.

3. ANALYSIS AND TESTS OF PHYSICAL AND CHEMICAL CHARACTERISTICS OF THE CONCRETE.

The percentage of ELT to be used is limited by the dosage of the aggregates in the mix. Different replacement percentages (both of the volume of aggregates and the total volume) were tested.
Although there is a limit which it is not advisable to exceed, there is no optimum percentage common to all applications. Depending on the application, it is necessary to estimate a dosage that modifies the properties required by the application. The greatest limitation is imposed by the compression strength, as determined by the standard applicable in each case.

In the second part of the study, and having identified the appropriate values for the first variables, new set of tests were conducted in which steel fibres were added along with the chips. In some cases, it was necessary to adapt approved tests for materials with different characteristics.

3.1. Characteristics of fresh-state concrete

Generally-speaking, dry consistency concretes are obtained and plasticisers or superplasticers therefore it need to be added to the mix. It has been found that the greater the amount of chip used in the mix the smaller the slump in the cone.

Test cylinder vibration

Abrams Cone

3.2. Characteristics of hardened concrete

Generally-speaking, a reduction is observed in the various mechanical properties analysed compared to the values obtained for the conventional concrete for three main reasons: loss of mineral skeleton of the coarse aggregate; change in the granulometric curve; and the incorporation of ELT material with properties different to those of the replaced aggregate. Nonetheless, in the specific tests of the fibre-added concrete, the concrete was found to behave better due mainly to the presence of the ELT steel fibres, whose behaviour was similar to that of conventional fibres.

Conclusions

- The changes in the concrete properties when materials from ELTs are added result in a loss of mechanical properties, the coarser materials, the higher loss. However, adding steel fibre from ELTs produces the opposite effect.

- For applications of concrete that require energy absorption and certain performances derived from improved freeze-thaw cycles, replacing part of the aggregates with rubber can be beneficial.

4. TECHNICAL AND ECONOMIC STUDIES

New Jersey barriers are of the most interesting applications of rubber-concrete. However, the use of these materials in this type of application is not as simple as might appear given the technical limitations and weaknesses identified.

- Difficulties in finding a company offering sufficient product manufacture guarantees.
- Technical limitations due to the decrease in certain properties.
- Problems with industrialising the manufacture of the concretes.

Conclusions

- The latest laboratory results indicate that the reference value for compressive strength (> 35 MPa) can be achieved by adding rubber chip alone. The following table shows the final dosage:

Chip replacement	7 - 10 %	**% by volume**

- At industrial level, no problems are anticipated as regards manufacturing the rubber-concrete, which can be made using the same equipment as for a conventional barrier.

- In economic terms, there are no major price differences between a traditional New Jersey barrier and one made from rubber-concrete. Moreover, it would be worth studying if savings on transportation costs are possible due to the weight reduction achieved.