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Conference report

An International Conference has been organized at The Kingston University at Thames, UK by Dr. M. Limbachiya. With his sustainable efforts 33 countries have participated and 130 papers were presented. This large number of participation shows global interest in the subject. The conference dealt with three themes; demolition waste, scrap tyre waste and glass waste.

Theme I, Demolition waste

More than 450 million ton/year the construction and demolition waste (C&DW) form the largest waste stream in quantitative terms within the European Union, apart from the farm waste [1]. If one excludes earth and excavated road material the amount of construction and demolition waste generated is estimated to be 180 million tons per year. This is over 480 kg/person/year.

In the European Union roughly 75% of the waste material is disposed to landfills, despite its major recycling potential. However, some of the member states, in particular Denmark, The Netherlands, and Belgium use about 80%. At present, the south European countries (Italy, Spain, Portugal, Greece) recycle very little of their C&DW. Their natural resources are of a sufficient quality and quantity to meet the demand for building materials at a moderate cost. Use of coarse as well as fine C&DW aggregate from demolished and rejected concrete has been discussed.

It is shown that the water absorption of both recycled coarse and fine aggregates is 7–10% more than the natural coarse and fine aggregates. Recycled aggregate concrete has shown high shrinkage, and 2–40% reduction of compressive strength. Maximum reduction occurred in concrete made both with recycled coarse and fine aggregates. While concrete only with coarse aggregate has shown only 2–10% lower compressive strength. Up to 30% coarse RCA can be used, without any modification in the mix design, with performance similar to natural aggregate concrete. It was concluded that the C&DW coarse aggregate can produce a range of concrete with acceptable compressive strength. Exceeding 30% water reducing admixtures or larger amount of cement is to be used, which will compensate for decrease in strength.

Use of fly ash is beneficial while using RCA. It modifies the pore structure; works as a filler and as pozzolanic material. It decreases chloride ion penetration, drying shrinkage and compensates for the strength loss. For higher percentage of RCA in structural concrete 25–35% fly ash is recommended.

It is also reported that, through an accurate crushing and sorting of C&DW material, it is possible to obtain grain size fractions (0.6–0.125 mm) with roughly homogenous chemical and mineralogical composition that can be directly re-utilized in the preparations of new mortars and concrete items. Further, reuse of the finer fractions in cement preparation, after suitable mixing with lime and subsequent calcinations process is proposed.

Curing condition also influence upon the quality of concrete. For example, steam curing increased 1 day strength but 28 and 90 days strength decreased. Steam curing decreased static modulus of elasticity in comparison to the water cured concrete. This diminished with the addition of increased C&DW aggregates. Steam curing decreased the drying shrinkage and increased the resistance against chloride ion penetration.

In a study done in Greece on the characterization of the recycled aggregates from masonry (RMA) and concrete (RCA), it was shown that calcite is the predominant phase. These are indications that these materials could partially replace the raw materials used in producing cement clinker. However, the potential demand for recycled aggregates as cement raw materials depends not only on their compositions but also on their steady supply and reliable logistics and this is an important key point for the specific application.

Washing plant pre-treatment, classification

RCA from demolished concrete is contaminated with different salts. These are washed, inspected carefully and classified. F.M. Convoy Ltd in UK has a fleet of 14 unconventional mobile concrete batch mixers and lorries to produce 25,000 tonnes recycled aggregate. They use special high pressure water washing plant, the only

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one of its type in the UK for cleaning up to 80 t/h of dirty raw feed material into reusable sand and aggregate has been installed.

Use of tile chips, foam concrete construction demolition were also discussed.

[1] European Commission, Directorate-General Environment, DG ENV.E.3 Management of Construction and Demolition Waste. Working Document no. 1, 4 April 2000. p. 1–26.

Theme II, used/post consumer tyres

The disposal of scrap tyre is a global problem. According to the Rubber manufactures,[1] scrap tyres are generated primarily from passenger vehicles (84%). The remaining scarp tyres come from aircraft or light and heavy trucks (15%), heavy equipment, and off road vehicles (1%). The major difference between passenger tyres and heavy truck tyres is the ratio of natural rubber to the synthetic rubber (1:2 or 2:1, respectively).

In a new radial passenger tyre, more than 50% of the rubber is used to construct the tread and sidewall. When scrap tyres are processed, the tread and sidewall components are shredded to produce single pass shreds, 2 in. (50 mm), or 1.5 in. (38 mm) shreds. Steel belts, bead wire and fabric insulation can all be removed to produce useable tyre chips.

There are two major markets for scrap tyres: (i) tyre derived fuel and (ii) in civil engineering (CE).

The major industries that use TDF are cement kilns, pulp and paper mills, industrial boilers and utility boilers. More than 550 kt of whole and shredded tyres are used each year in the European countries The chemical elements in the ash are incorporated in the mineral structures and have no negative impact on clinker quality.

In civil engineering one of the markets with potential for growth is scrap tyre rubber modified concrete. It includes scrap tyre chips and/or crumb rubber as source for natural aggregate in geotechnical fills, concrete and asphalt pavements. It is shown that the concrete workability, mass density, compressive and tensile strength, modulus of elasticity decreases with increase in rubber content. The tyre concrete is directly inapplicable in slab structures bearing load, but these can be successfully used as base under these slab structures (in road base, floor base and pavements). On the other hand the improvement in certain properties like tenacity, impact resistance, thermal and accoustic isolation, electrical insulation, vibration damping etc make it attractive.

It is reported that the use of rubber aggregates in OPC mix concrete produces a marked reduction in concrete compressive strength. But this difference is less when cement paste coated rubber aggregates were used. However, if the amount of rubber in the concrete is limited, a normal strength concrete can still be produced with potential uses in non-structural applications.

The ability to produce cost effective rubberised concrete products for industry depends on over coming some of the practical production difficulties such as surface finishing and aggregate segregation during mixing. A further difficulty is the high cost of the rubber chips. This situation should improve after the imposition of the landfill ban in UK for example in 2006 as the cost of the alternatives to recycling increases.

Attractive areas are abrasion resistance, shock resistance.

The addition of rubber aggregate is thus of dual interest: it improves the thermal behaviour of cementing material while reducing sensitivity to moisture, thereby preserving storing thermal performance within a wet media.

One of the innovative way of using the dust produced during the production of aggregate by shredding process is in producing aerated concrete. It deals with mixing rubber dust, clay, cement and a proteinic foaming agent. It is reported that this concrete has at least 3 times lower coefficient of sorptivity.

Chemical recycling

Chemical recycling process are at present a potential alternative for treating scrap tyres. Co-combustion of tyres in cement kilns is today the process most used the one which is expected to grow more in the near future. Incineration has achieved for the moment less success with tyres than with other wastes. Gasification and pyrolysis are the more innovative chemical recycling processes. They are at present being proved on a commercial scale. There are many different technologies available at present in the market for tyre pyrolysis and gasification, specially for pyrolysis.

Theme III, Glass waste

Recent work has shown the feasibility of using waste glass as filler in road pavement, as batch addition in melting hazardous waste, in civil engineering, in development of foam glass, as flux in production of bricks and ceramic industry etc. The development of foam glass is particularly attractive, and is known from 1930s. But its use was limited due to high cost. However its extra ordinary properties; low thermal conductivity with no flammability, thermal and chemical stability,

[1] Rubber Manufacturing Association. Scrap Tyres. http://www.rma.org/scraptyres.2004.

suggests a growing application as a substitute for organic foam.

The results of using foaming agents; SiC, Silicate waste from polishing the stoneware tiles (sludge), are reported. It is shown that SiC powder was very effective in producing foamed glass when mixed to the glass powder with a concentration ranging from 0.1 to a few weight percent. It is shown that they posses both structural and insulating properties because of their high density and thermal conductivity. The sludge and the glasses from cathode ray tubes (CRT) appear to be extremely promising. The foams obtained from larger sludge content are denser, with small isolated pores and their compressive strength is high.

Three types of carbonaceous substances have been tested; PFA, Carbon Black and PMMA, out of these three type of glass foams GC-CB have shown the best mechanical properties. These foams differ from the others as they have around 95% closed porosity for density not lower than 0.3 g/cm^3, GC-PFA foams, GC-_PMMA foams and GC-CB foams with density lower than 0.3 g/cm^3 have a porosity prevalently open (75–85%, 70% and <75% respectively), which consequently decreases the compressive strength.

Use of glass in concrete industry

When waste glass is used as aggregate—the demand of water increases, consequently the strength decreases.

Concrete made of waste glass as coarse aggregate is highly unworkable and unsatisfactory regardless of the type of cement and superplasticizer used. But cathode ray tube (CRT) glass can be successfully incorporated as fine aggregate in a concrete mix, providing strength and workability properties equivalent to a control mix using traditional aggregate material. Leaching of barium and lead can be reduced by addition of PFA and GGBS. The glass is however susceptible highly to ASR. This detrimental effect can be minimized through the use of established mitigation techniques, for example; 20% cement replacement of super-classified PFA and metakaoline could totally mitigate ASR expansion of post-consumer cullet aggregate in concrete. However care should be taken as PFA might contain radio active elements.

The used matt wastes show pozzolanic activity and their addition to standard formulations leads to concrete and mortars having better mechanical properties and low porosity than those usually obtained when calcarious filler is used.

In another study it is shown that the slump increased progressively with the increase in the glass sand replacement. 10% higher compressive strength with 50% replacement than that developed by the control mixes. This mix showed the best ultrasonic pulse velocity. This shows that the 50% glass sand replacement is the optimum proportioning for optimal mechanical properties.

The shrinkage properties of glass concrete are comparable to that of concrete with normal aggregate (gravel). The use of large glass blocks in concrete panels will not necessarily cause large cracks due to the stress-reducing relaxation of the matrix.

Glass as cement replacement material

The use of milled waste glass as a cement replacement material in concrete seems feasible especially for low substitutions. This approach gives an alternative to use waste glass not only to protect the environment by saving more landfills but also to reduce CO_2 emission per ton of cement by consuming less cement.

As a flux

Powdered glass works as a flux, 5–10% levels in brick and pavers helps in the vitrification process. This increases compressive strength, and reduction in water absorption.

It decreases energy consumption.

Apart from the energy savings, it produces concrete of enhanced freeze–thaw properties, less water absorption, reduction in CO_2 emission, which assists the manufacturer in achieving the energy(CCL) and emission (EU ETS) related environmental legislative taxation targets.

86–96% cleaned and crushed end of life (EOL) CRT glass can be used as a glaze material for low fired ceramics. The valuable properties of CRT glasses can be utilized to the full and can give a high value recycling for CRT glasses.

ECO cement

Eco cement is developed by 50% replacement of cement clinker by waste glass, it has compressive strength similar to normal Portland cement. It requires low amount of water, which results in high workability at low W/C.

The main difference between the glass cement pastes and the reference Portland cement, is related to the decrease in the size and amount of CH, caused by the consumption of CH as a result of pozzolanic reaction involving glass grains. No ASR was found.

Use of glass as fine aggregate in a hot rolled asphalt wearing (HRA) course mixes. It is shown that it is feasible to use glass as a sand replacement in a HRA wearing course mix.

It was emphasized in the conclusion that "It is preferential to use recycled glass to make more glass, rather than as a replacement for aggregates". Whereas energy consumption decreases as more recycled glass is used in glass manufacture, diversion of the glass to aggregates use increases the energy consumption as the amount of glass recycled is increased.

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