MANUFACTURE OF AGGREGATES FROM WASTE SILT AND FINES

Richard Lupo, Mark Tyrer, Neil Tsang, Fintan McKeever[1] and Chris Cheeseman

Department of Civil and Environmental Engineering, Imperial College, London SW7 2BU

[1]Duo Equipment, 1 Rye Hill Office Park, Allesley CV5 9AB

INTRODUCTION

Recycling of excavated soils from construction sites has become a viable business in the UK as a result of washing and screening processes which allow the extraction of coarse aggregate and sand. A major waste stream from this process is fines or silt materials, typically with a particle size < 75 μm. This is filtered from the wash water and sent to landfill. The associated transport and disposal costs reduce the financial viability of the aggregate extraction process. Disposal of silt also represents loss of a potential resource and uses valuable landfill void space.

The objective of this ongoing research project, funded by the Defra Waste and Resources R&D programme, is to convert waste fines or silt, into aggregate. The processing technology developed needs to be located at the aggregate washing plant so that silt waste is no longer generated and aggregate washing moves towards becoming a zero emission facility. Processing silt to aggregate also reduces the need for virgin aggregates and conserves landfill void space.

Silts have previously been converted into products by high temperature sintering. The energy costs and environmental issues associated with sintering mean this research aims to develop ambient temperature processes. Following full characterisation of waste silts and fines the research is investigating innovative processing using cementitious binders and polymer additives to produce aggregate materials.

Figure 1. Aggregate washing plant in operation. Coarse aggregates and sand can be separated out and sold.

Figure 2. The waste silt generated from aggregate washing is separated from the wash-water by filter press. This is generally sent to landfill.

CHARACTERISATION

Five UK aggregate recycling plants were visited to assess quantities of silt produced and collect samples. Water content, particle size analysis, XRD, TGA and chemical testing were completed to characterise the waste materials.

It was found that a total of 1000 tonnes per day of waste silt was generated from the five plants, which represented approximately 20% of input soil. Characterisation showed the absence of chlorides and sulphates, which are potentially problematic in aggregate used for structural concrete. XRD analysis and optical microscopy showed that the silts were composed of high proportions of clay and quartz particles.

Water Content (wt %)	Organic Content (wt %)	d_{50} (μm)	pH	Surface Area (m^2/g)
31.3 – 36.9	1.5 – 3.8	13.4 – 27.0	7.0 – 8.8	12.1 –14.5

Table 1. Selected characteristics of the waste silt

STRENGTH OF BINDING SYSTEMS

Cylindrical samples of various combinations of silt, sand, Portland cement (PC) and polyvinyl alcohol (PVA) were prepared and allowed to cure under laboratory conditions for 28 days.

The water content of the silt was a key factor controlling strength development. Water to cement ratios affect the strength of concrete systems and sand was used to reduce the relative water content. Therefore the increase in strength of samples with increasing replacement of silt with PC was due to reduced water to cement ratio as well as increased levels of binder.

Marked increases in strength occurred with even small additions of PVA. This was due to the adhesive properties of PVA, it absorbs water, effectively reducing the water to cement ratio and it acts as a rheological aid allowing increased packing of individual particles during processing.

The compressive strengths obtained for silt containing mixes are comparable with the strengths of concrete used for non-structural applications.

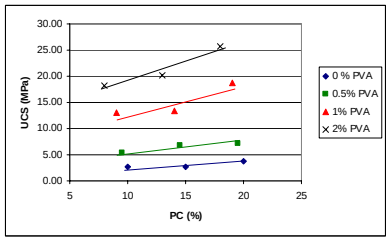

Figure 3 Increasing PC and PVA content raised UCS not only due to increased presence of binders but also due to increase water to cement ratios (sand:silt ratio 0.4).

AGGREGATE TESTING

To manufacture aggregates, a freshly prepared batch of sand, silt and binder (2% PVA, 18% PC) was extruded through a 6.25mm sieve and the particles formed were pan pelletised. Samples were cured for at least 28 days prior to testing.

Aggregates were subjected to an increasing compressive load and the deflection after each load increase was measured. The amount of fines generated was determined at the end of the test. The results demonstrated that trial aggregates were stronger than commercially available lightweight aggregate. Deflection and fines generation were comparable to those obtained from aggregate produced from existing washing plant, indicating potential viability for use in a range of applications such as trench backfill and sub-base.

Figure 4. Sustainable aggregate produced from waste silt and fines.

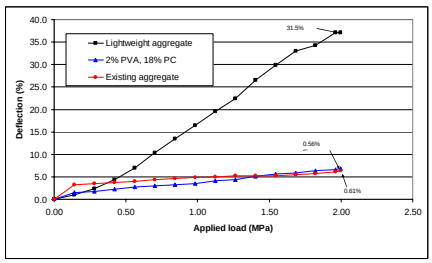

Figure 5. Load testing of aggregate produced from the silt, sand, PVA and PC system.

CONCLUSIONS

Approximately 1000 tonnes per day of waste silt is generated from five UK soil washing plants. This represents approximately 20% of the input soil. The silt is composed mainly of quartz and clay particles with water contents typically in the range 30-35% by mass. Extrusion and pelletising of silt/PC/sand/PVA systems allows the production of aggregate particles that have appropriate properties for use in backfill and other low grade bulk applications. Increasing PC and PVA content results in aggregates with increased strengths. The project has the potential to develop recycling of excavated soils from construction sites into a zero waste process.

REFERENCES

British Standards Institution, (1990a), BS 812-110:1990, Testing aggregates - Part 110: Methods for determination of aggregate crushing value (ACV), *British Standards Institution*, London.

Huang C., Pan J.R., Sun K.D. and Liaw C.T., (2001), Reuse of water treatment plant sludge and dam sediment in brick-making, *Water Science and Technology*, 44, 273-277.

Temimi M., Camps J.P. and Laquerbe M., (1995), Valorization of fly ash in the cold stabilization of clay materials, *Resources, Conservation and Recycling* 15, 219-234

Kim J.H. and Robertson R.E., (1998), Effects of polyvinyl alcohol on aggregate-paste bond strength and the interfacial transition zone, *Advanced Cement Based Materials*, 8 66-76.

ACKNOWLEDGEMENTS

We would like to acknowledge Defra for project funding and Neil Carrigan for technical advice and support.