Proceedings of ICXRI 2010
International Conference on X-Rays & Related Techniques in Research & Industry
June 9 – 10, 2010, Aseania Resort Langkawi, Malaysia

Microstructure Study between Lightweight Aggregates and Cement Matrix

Khairul Nizar Ismail & Kamarudin Hussin
School of Environmental Engineering
Universiti Malaysia Perlis
nizar@unimap.edu.my

Abstract- This paper presents a study of lightweight aggregates microstructure using Scanning Electron Microscope with Energy Dispersive Spectrometer (SEM-EDS). This paper examined the topography of the interfacial zone and the characteristic of the surface pores of the lightweight aggregate concrete. The porous surface of LWA improved the interfacial bond between the aggregate and cement paste by providing interlocking sites for the cement paste forming a dense and uniform interfacial zone.

I. INTRODUCTION

The microstructure of interfacial zone (IZ) of one kind of lightweight aggregate concrete was studied using Scanning Electron Microscope (SEM) equipped with an energy dispersive X-ray analysis system, as well as through back-scattered electron imaging. This paper examined the topography of the IZ and the characteristic of the surface pores of the lightweight aggregate concrete. A weak interfacial zone will have serious effect on durability. The influences of IZ on concrete strength and permeability are so great that IZ is regarded as one phase of concrete in addition to the aggregate and cement paste [1].

Concrete solidifies and hardens after mixing with water and placement due to a chemical process known as hydration. The water reacts with the cement, which bonds the other components together, eventually creating a stone-like material. The reactions are highly exothermic and care must be taken that the build-up in heat does not affect the integrity of the structure. Cement is made by heating limestone with small quantities of other materials (such as clay) to 1450°C in a kiln. The resulting hard substance, called ‘clinker’, is then ground with a small amount of gypsum into a powder to make ‘Ordinary Portland Cement’, the most commonly used type of cement (often referred to as OPC).

Portland cement is a basic ingredient of concrete, mortar and most non-speciality grout. The most common use for Portland cement is in the production of concrete. Concrete is a composite material consisting of aggregate (gravel and sand), cement, and water. As a construction material, concrete can be cast in almost any shape desired, and once hardened, can become a structural (load bearing) element. Portland cement may be gray or white.

II. EXPERIMENTAL METHODS

(i) Ordinary Portland Cement

Ordinary Portland Cement (OPC) with specific gravity of 3100 kg/m3 and fineness of 410 m2/kg was used. Portland cement is simply a mixture of limestone and clay heated in a kiln to 1400 to 1600 degrees centigrade The 28- day mortar cube strength was 55 MPa and the oxide compositions of OPC are given in Table 1.

Table 1: Typical compositional analysis (wt.%) of cement

	CaO	SiO_2	Al_2O_3	Fe_2O_3	MgO	SO_3
OPC	63.2	20.6	5.0	3.1	2.8	0.6

(ii) Lightweight aggregate(LWA)

The particle density of lightweight aggregates (LWA) used in this research is 1.3147 g/cm^3 and loose bulk density is 1093 kg/m^3 (course aggregates). These results gratify the specification of British Standard 3797[2]. The lightweight aggregate is a synthetic aggregate manufactured from fly ash. The aggregate crushing strength was 4.2 MPa. The particle shape, surface texture and pores of LWA may be expected to influence the workability, aggregate/cement ratio and water requirement of a concrete mix..

(iii) Lightweight Aggregate Concrete (LWC)

The experimental work in this research is based on LWC with cement content of 450 kg/m^3 and water/cement ratio of 0.55. Table 2 shows the mix proportions of the LWC.

LWC cubes were made during the experiment. The cubes were water-cured for 28 days. Cube compressive strength was tested at 28 days. Small sections of LWC were cut with a diamond saw from the 100mm test cubes at 28 days. Sample was then carbon coated for SEM examination. The interfaces of aggregate/cement paste for both polished and fractured samples were examined. A JEOL 6460 SEM was used to examine the microstructure of the interfacial zone.

Table 2 : Mix proportions of the LWC (kg/m^3)

Cement	LWA	Sand	Water	w/c ratio
450	700	700	250	0.55

III. RESULTS AND DISCUSSION

Figure 1 show the distribution and sizes range of voids on cross section surface. The surfaces are irregular and the voids appear to be distributed fairly. These figure show that the pores are interconnected, and that overall structure of the pellets is porous. The voids appear to have been formed by gases escaping through a melted material [3]. The pore size distribution is very important. Fine pore structure can result in poor sintering process, insufficient diffusion of air into and combustion products out of the pellets.

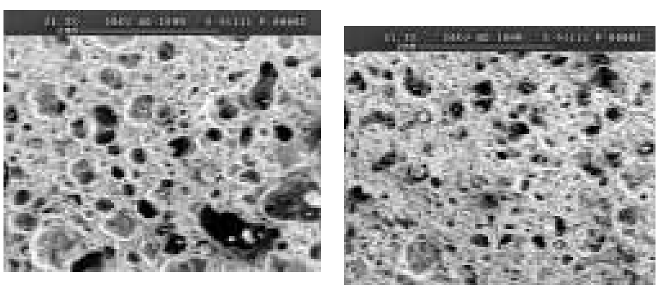

Figure 1: Size and pores in the lightweight aggregates

Figure 2 shown that the LWA surface is not as smooth as normal aggregate. At the surface of the LWA, cement paste is trapped in the pores as shown in Figure 3. Cement paste has infiltrated the surface pores of the lightweight aggregate to some depth. The presence of surface pores provides the interlocking site for cement paste to form a better interfacial bond at the interfacial zone [4].

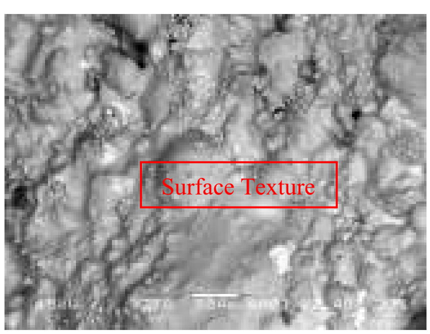

Figure 2: Surface texture of lightweight aggregates (LWA)

The microstructure of the cross section is shown in Figure 3. It is seen that the boundary between the cement matrix and the LWA surface is not distinct showing that the LWA bonds tight and continuous with the cement matrix. The well-bonded interfacial zone is a characteristic of higher strength development of the LWC.

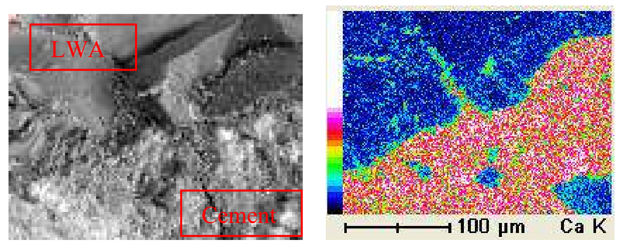

Figure 3: SEM view of the LWC showing the lightweight aggregate bonded with cement matrix

IV. CONCLUSION

There is a potential for producing lightweight aggregates from fly ash in Malaysia. It can be utilized in producing a moderate strength concretes. The porous surface of LWA improved the interfacial bond between the aggregate and cement paste by providing interlocking sites for the cement matrix forming a dense and uniform interfacial zone.

ACKNOWLEDGMENTS

The author would like to express his gratitude to the Universiti Malaysia Perlis for funding the project under short Term Grant Scheme (9001-00064).

REFERENCES

[1] T.Y Lo & H.Z Cui, Effect of porous lightweight aggregates on strength of concrete, Materials Letters 58 (2004) 916– 919.

[2] British Standard 3797: “Specification For Lightweight Aggregates For Masonry Units and Structural Concrete”, 1990

[3] M.-H. Zhang, O.E. Gjorv, Microstructure of the interfacial zone between lightweight aggregate and cement paste, Cem. Concr. Res. 20(4) (1990) 610– 618.

[4] R.N. Swamy and G.H Lambert, (1981), ‘The Microstructure of Lytag Aggregate’, The International Journal of Cement Composite and Lightweight Concrete,