

## CHAPTER V

### CONCLUSIONS AND RECOMMENDATIONS

#### 5.1 Conclusions

##### 5.1.1 The Clinker Analysis

The burning of raw mix at 0% to 20% of each petroleum sludge addition in the laboratory at 1,450 °C for a period of 90 minutes found that the results from the XRD and the chemical composition of synthetic clinkers were similar to Portland cement. The replacement up to 10% can reduce the amount of C<sub>3</sub>A, alumina ratio (AR) and silica ratio (SR) but can increase the amount of C<sub>4</sub>AF. Moreover, the addition of petroleum sludge trended to decreasing free lime value. The utilization of petroleum sludge in co-processing can impact on some properties of clinker

##### 5.1.2 Compressive strength

The compressive strength results concluded as follow:

1. According to the relationship of the compressive strength and curing time, the compressive strength increased with increasing curing time and the highest curing time at 28 days. Most of all samples were passed the ASTM standard.
2. The compressive strength of mortars decreased with increasing percentage addition of petroleum sludge up to 20% by weight. Therefore, the addition of petroleum sludge had effect on the compressive strength of mortars.

##### 5.1.3 Leaching Tests

The short-term leaching test results of chromium, nickel, zinc and lead can be concluded as follow:

1. With the additions of heavy metals petroleum sludge up to 20 percent by weight, the concentrations of chromium, nickel, zinc and lead did not

exceed the standard value of the U.S.EPA, the Notification of the Ministry of Industry No.6 B.E. 2540 (1997) and the Notification of the Ministry of Industry B.E. 2548 (2005).

2. The concentrations of chromium, nickel, zinc and lead that were leached by the Waste Extraction Test of the Notification of the Ministry of Industry B.E. 2548, were higher than those of the U.S.EPA and the Notification of the Ministry of Industry No.6 B.E. 2540 (1997).

3. The concentration of lead could not be detected in leaching solution due to a very low quantity.

### **5.1.3 The Sequential Extraction Test**

The sequential extraction test results of chromium, nickel, zinc and lead can be concluded as follows:

1. The concentrations of chromium, nickel, and zinc were more extracted in fraction 3 and fraction 5, in which heavy metals were bound to iron and manganese oxide, and where most of the heavy metals were more stable.

2. When the extracted concentrations of chromium, nickel, and zinc at fraction 1 (which can easily be leached into the environment) were compared with the surface water quality standard of the Notification of the Ministry of the National Environment Board No.8 B.E. 2537, they were lower than the standard value.

3. The concentration of lead could not be detected due to a very low quantity.

## **5.2 Recommendations**

1. The leaching behavior of many heavy metal and long-term of heavy metals should be further studied.

2. The forming of new compound of heavy metals in the phase of clinker should be deeply studied because it will provide more understanding in leaching behavior of each metal.