

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

From the experimental work and analyses carried out, the following conclusions can be drawn.

6.2 The effect of mix proportions of multiple blended binders on the workability of fresh concrete

Referring to the result and discussion from the previous chapters, it is found that the multiple blended binders may contribute to the enhancement of concrete workability.

The multiple blended binders material with MIRHA, SF and PFA as fine particles and spherical form of low-calcium fly ash particles has been credited to influence the rheological properties of cement phase and causes a reduction in the amount of water required for a given degree of workability compared to OPC cement paste. The spherical shape, smooth glassy texture and finer particle size distribution of MIRHA, SF and PFA may provide a greater plasticizing effect when compared to OPC mixed particularly at higher replacement level.

The multiple blended binders concrete is having less concrete spread diameter compared to OPC. Among three blended cement prepared and tested, multiple blended binders containing OPC:5%MIRHA:SF:PFA shows the highest slump test values followed by OPC:10%MIRHA:PFA: and OPC:10%MIRHA:SF:PFA. So, multiple blended binders concrete using waste product can still maintain the workability by utilising superplasticizer. Even this waste material can cause a reduction in height of slump.

6.3 Mechanical Properties of Multiple Blended Binders Concrete

1. Incorporating superplasticizer in the mix can further increase the amount of replacement of cement with MIRHA+PFA+SF. Sp can also allow the increase of content of cement replacement material if compared with OPC manual.
2. The optimum replacement level of MIRHA+PFA+SF with Sp to produce optimum compressive strength is with 16 types mix proposal. Concrete containing 5%MIRHA+PFA+SF was able to attain 86.53 N/mm^2 at 28 days. With the addition of Sp, the replacement level can be increased up to 100% to achieve slump height 50mm as per mix design.
3. Flexural strength, tensile splitting strength and the equivalent cube compressive strength of MIRHA+PFA+SF concrete with Sp taken at 28, 56 and 90 days are higher than the OPC control concrete on the values of these tests. The relative difference of the flexural strength for 5%MIRHA+PFA+SF concrete with Sp cured in water at 28 days was 25.6% more than normal concrete flexural strength. For the tensile splitting strength, the relative difference was 23.1%, and equivalent cube compressive strength was 24.5% more than normal concrete if compared with multiple blinded binders concrete. The equivalent cube compressive strength for MIRHA+PFA+SF concrete irrespective with Sp is higher than the standard cube.
4. The ultrasonic pulse velocity value for 5%MIRHA+PFA+SF concretes with Sp was higher compared to the OPC control concrete. However, the pulse velocity values recorded were above 4.4 km/sec at 28 days, irrespective of their curing condition. BS EN 12504-4:2004 categorized these concrete as good or even excellent. In other words, the multiple blinded binders concrete result measured was the velocity of high-frequency ultrasonic pulse passed through a concrete member between two transducers, with higher velocity taken to reflect higher density and hence a better quality of concrete.

5. The rebound number for MIRHA+PFA+SF concretes was bigger compared to the OPC control concrete, and the relative difference was 22.3% respectively. Increase in replacement with MIRHA resulted in a increase in the rebound number. The multiple blended binders concrete can be used as cement hardener or a part of structure repair material. The multiple blended binders concrete also contributes to green building and sustainability environmental.

From the experimental results obtained, the proposed computer program correlates the relationship between compressive strength and other mechanical strengths.

6.4 Durability of Multiple Blended Binders Concrete

1. The coefficient of permeability of 10% MIRHA+PFA+SF was 5.4×10^{-18} m/sec is lower than the OPC was 5.9×10^{-18} m/sec. The MIRHA+PFA+SF concretes were less permeable than the OPC control concrete, i. e. about 0.9 times respectively.
2. A linear relationship between permeability (gas permeability) and compressive strength existed, in which the compressive strength increases with decreasing permeability. Therefore, the multiple blended binders concrete will increase durability properties. Indirectly, the multiple blended binders concrete will also make a pro-long life span of the concrete.

6.5 Developing Computer Programme Mix proportions Weight of Multiple Blended Binders utilizing Local Waste Product for Industrial friendly User

1. The new computer program of mix proportions was designed due to industry needs and friendly user. This program also was design using Microsoft office excel to ensure that it can used easily.

2. Based on this computer program, the industry user can get more information regarding the ratio of multiple blended binders, the volume and the cost needed to produce this type of cement replacement.
3. Lastly, the industry user is also free to select the type of test, the volume of mix proposal, the strength and the age of concrete to get the actual type mix proposal multiple blended binders.

6.6 Summary

1. From the experimental work and analyses carried out, it can be concluded that the compressive strength of Grade 70 concrete with up to 28% replacement level of MIRHA+PFA+SF is better than the plain OPC concrete. To increase the replacement level higher, the use of a superplasticizing admixture is necessary to ensure workability is maintained.

When the MIRHA+PFA+SF is blended in the concrete, the workability will decrease and humidity reduced but with admixture like superplasticizer this increases the workability and prevents from low slump test.

2. The present results on MIRHA+PFA+SF concrete indicates good long term mechanical properties in terms of strength due to low cement content.
3. Sp addition does help in strength and durability due to the enhancement in pore refinement.
4. Durability performance in terms of gas permeability, charge passed using gas hydrogen penetration test showed that MIRHA+PFA+SF concrete performed better at par to that Portland cement concrete provided the moist curing is provided.

5. MIRHA+PFA+SF concrete requires prolonged moist curing to perform better than those of plain OPC concrete due to its slower rate of pozzolanic secondary reaction.

6.7 Recommendations for Future Research

For future research, the following areas are recommended to be looked into:-

1. Study the effect of carbon content and lime saturation factor of binders containing pozzolanic materials in multiple blended binders concrete system to cementitious properties and performance.
2. Investigate the effect of MIRHA qualities in term of carbon content, fineness and chemical compositions to the performance of binders containing these material.
3. Investigate the optimum microwave incinerator temperature and time of rice husk in producing highly reactivity MIRHA. The composition of carbon may be reduce and the composition of SiO_2 may increased by microwave incinerator the rice husk at proper temperature and time.
4. Investigation on other durability properties of MIRHA+PFA+SF concrete such as pores size distribution using mercury intrusion method and corrosion resistance. Therefore, this ensures the multiple blended binders concrete product to avoid from crack, spall or rust stain during application for the real structure development.