ABSTRACT

There are numerous studies that assess the effects of changes in the water/binder (w/b) ratio and binder content on strength and durability properties of concrete. However, limited information is available on the extent to which changes in w/b ratio and binder content affects concrete strength and durability. This study focused on the sensitivity of concrete to changes in these parameters to further the understanding of the material by determining the importance of the parameters on the resultant concrete properties and providing practical guidelines for the mix design process.

Concrete test specimens were made using two w/b ratios (0.45 and 0.65), two binder contents (350 and 450kg/m^3) and three binder types PC (plain Portland Cement), 70/30 PC/fly ash (FA) and 50/50 PC/ground-granulated blastfurnace slag (GGBS). One parameter was varied at a time. Compressive strength tests were conducted at 3, 7, 14, 28 and 56 days and durability index tests at 28 and 56 days.

The results indicate that increases in w/b ratio lead to lower compressive strengths and increased permeability, sorptivity and chloride conductivity. Increases in binder content have beneficial effects on compressive strength; however, this trend does not continue indefinitely and is related to the paste content range, aggregate content and grading. Furthermore, binder content increases proved to be detrimental to concrete durability by decreasing the oxygen permeability (OPI) and increasing the water sorptivity (WSI) and chloride conductivity (CCI) indices. In general, for all the binder types investigated, both the strength and durability properties were more sensitive to changes in w/b ratio than binder content.

The compressive strength of FA concretes was the most affected by a change in w/b ratio. The sensitivity hierarchy of compressive strength of PC and GGBS concretes to a change in w/b ratio varied with age. For the three different binder types, sensitivity of compressive strength to changes in w/b ratio generally decreased with age. The extent to which a change in binder content affects compressive strength varies with age and no clear binder type hierarchy is evident. The w/b ratio therefore remains the controlling factor of compressive strength.

For the parameters tested, the OPI of FA concretes exhibited the highest sensitivity to changes in w/b ratio followed by GGBS and PC concretes respectively. Moreover, GGBS concretes were the most sensitive to changes in binder content followed by PC and FA concretes. As with compressive strength, sensitivity of OPI to changes in both w/b ratio and

binder content decreases with age. The sensitivity variance of OPI between changes in w/b ratio and binder content is considered to be minimal, less than 5.0%, and therefore both of these parameters need to be carefully considered in the mix design process when assessing permeability requirements.

The results also indicate that the sensitivity of WSI to changes in w/b ratio follows a similar pattern to compressive strength and decreases in the following order: FA > PC > GGBS. Furthermore, this sensitivity increases with age apart from one FA specimen. The sensitivity trends for binder content variations are not well defined; however, they generally decrease with age. W/b ratios and paste contents therefore need to be kept as low as possible in concrete mixes.

CCI sensitivity to changes in w/b ratio decreases in the following order: PC > FA > GGBS. The sensitivity to changes in binder content generally decreased as follows: GGBS > PC > FA. The extent to which a change in w/b ratio and binder content affects CCI generally decreases with age. These findings reiterated the need to control the paste volume. Adopting the highest replacement levels of GGBS leads to the lowest chloride conductivity. However, these concrete mixes exhibit the highest sensitivity to changes in paste content.