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Effect of cement grade on physico-mechanical properties of cement-sand mortar

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ABSTRACT

This paper discusses the effects of cement grade on physico-mechanical properties of cement sand mortar. Flexural strength test, compressive strength test and drying shrinkage test were carried out on mortars made from three types of cements, i.e. Type 1 (Grade 42.5), Type 2 (Grade 32.5) and Type 3 (Grade 32.5). The tests were conducted at 7, 14 and 28 days and the results obtained showed that cement grade 42.5 has higher flexural strength, compressive strength and drying shrinkage than cements grade 32.5. Even though, higher strengths are advantage in concrete, mortar is not supposed to have strength stronger than the units it is bonding. Therefore, based on the experimental results obtained, it can be concluded that cement Grade 32.5 is more suitable for use as mortar than Grade 42.5.

Keywords: Cement grade, Cement-sand mortar, Flexural strength, compressive strength, drying shrinkage

1. INTRODUCTION

Cement is a key and popular construction material; it is classified according to its compressive strength at 28 days. When tested, if the 28 days strength is less than 32.5N/mm^2, it is called 32.5 grade of cement. If the 28 days strength lies between 32.5 to 42.5N/mm^2, it is called 42.5 grade of cement. If the 28 days of strength lies between 42.5 to 52.5N/mm^2, it is called 52.5 grade of cement (Adewole, Kazeem K et al., 2015; Jackson and Dhir, 1996). Currently, In Nigeria, there are 32.5 and 42.5 grades of Portland-limestone cement (Adewole, Kazeem Kayode et al., 2015; Akshay Baxi et al., 2018; Ukpaka Chukwuemeka Peter and Okochi Godspower Ikechukwu, 2018), with 32.5 grades being phased out gradually.

Mortar is composed of cement and sand. When water is mixed in with this product, the cement is activated. Mortar is used to hold together blocks, bricks, stones etc. Cement act as adhesive which when set binds particles of fine aggregate together to produce mortar. About half of the amount of Portland cement consumed in building construction is used in masonry and plastering (Domone and Illston, 2010). Cement-sand mortar is adjudged to be the best mortar for external plastering work because it is practically non-absorbent. It is preferred more than lime mortar in damp climates (Punmia et al., 1993; Angeline Mary et al., 2015). In fact, the main advantage with cement based mortar is that it reaches maximum strength in only 28 days compared with 90 days for lime based mortar (Ahmed and Kamau, 2016). BS 5628 (BS5628-1:, 2005) designated cement mortar into 4 groups as shown in Table 1.

Table 1 Different designations of cement based mortars

	Mortar designation	Compressive strength class	Mix Ratio	Compressive strength at 28 days (N/mm^2)
Increasing ability to accommodate movement, e.g. due to settlement and moisture changes	(i)	M12	-	12
	(ii)	M6	1: 3 to 4	6
	(iii)	M4	1: 5 to 6	4
	(iv)	M2	1: 7 to 8	2

(*Sources*: (BS5628-1:, 2005))

Selection of the correct grade of mortar is an important factor in the performance of a wall. The mortar must have sufficient strength, be durable, resist rain penetration as much as possible and yet be flexible enough to accommodate slight movement within the wall.This paper studies the influence of cement grade on the properties of cement mortars.

2. MATERIAL AND METHODS

2.1. Materials

Cement

Three types of Portland-limestone cements were used in conducting this research. They were Dangote cement of grades 42.5 and 32.5 (hereafter called "Type 1" and "Type 2") and Bua cement grade 32.5 (hereafter called "Type 3"). They all complied with CEM II of (NIS-44., 2003) Part 1.

Fine Aggregate

River sand was used as fine aggregate, it is clean, sharp and free from clay, loam, dirt and any other deleterious materials. The fine aggregate is dried so that water cement ratio would not be affected. Sieve analysis was carried out on the aggregate.

Water

The water used for the research was free from salt and other deleterious materials.

2.2. Methods

Mortar Production

Mortar is a mixture of a binder material and sand. The mortar used in this study is one part binder material to three parts and (1:3) as specified in BS EN 196-1 (EN, 1995). The mortar was used for flexural strength test and compressive strength test.

Mortar Flexural Strength Test

The centre-point loading method was used to determine the flexural strength as specified in BS EN 196-1 (EN, 1995). Fifty four (54) prismatic test specimens measuring 40 millimeter × 40 millimeter cross-section and 160 millimeter length were produced and tested for flexural strength in accordance with BS EN 196-1 (EN, 1995) recommendations. These specimens were casted, de-molded the next day, and then cured in accordance with the standard procedure in water until tested at 7, 14 and 28 days.

Mortar Compressive Strength Test

From the prism prepared for flexural test (40x40x160mm), a cube of 40mm x 40mm x 40mm was cut from the broken half of each of the prism after flexural test as specified in BS EN 196-1 (EN, 1995). Compressive test was then conducted on each cube.

Drying Shrinkage Test

The test was conducted on the flexural test specimens before the flexural test by measuring its length to determine any shrinkage after thoroughly drying them, in accordance with BS EN 196-1:2005

3. RESULTS AND DISCUSSION

3.1. Mortar sand

The sand used for the study has specific gravity 2.53 and found to be suitable for concrete making as it complied with grading zone 2 of BS 882 (BS882, 1983) as shown by its particle size distribution in Figure 1.

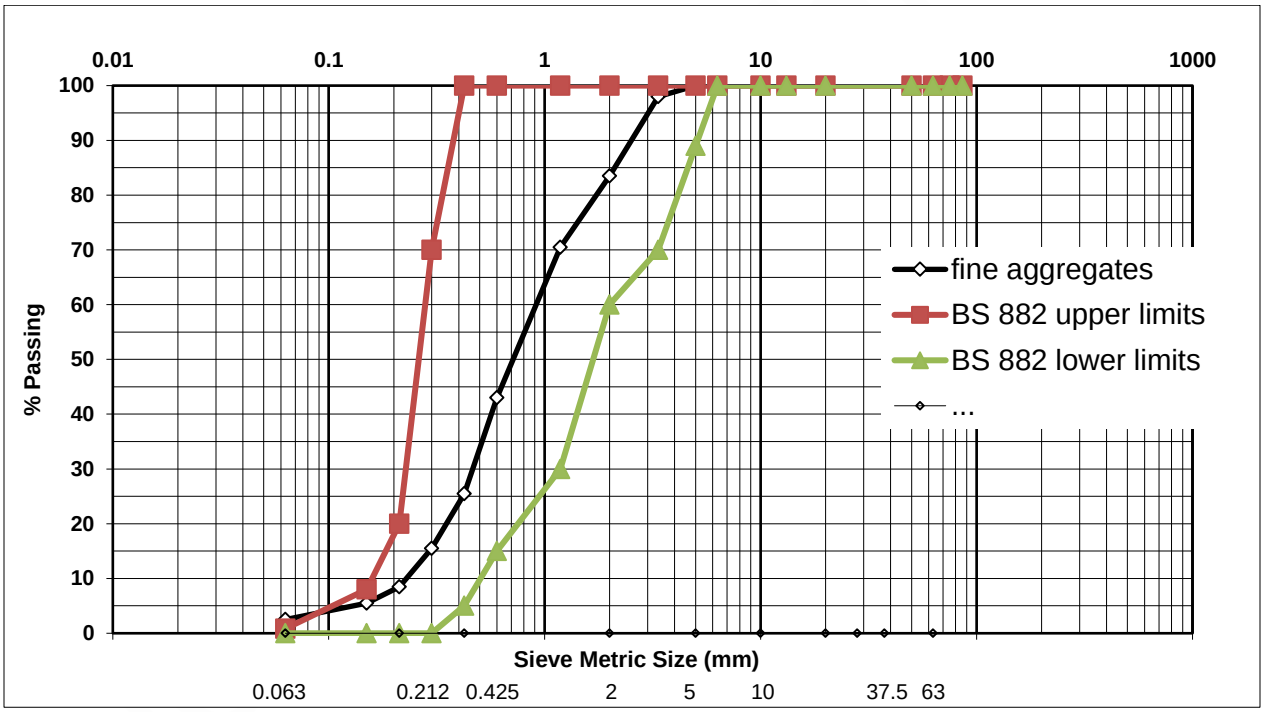

Figure 1 Particle size distribution of the Fine aggregate

3.2. Mortar Flexural Strength

From the results of the mortar flexural strength test presented in Figure 2. The mortar flexural strength increases linearly with curing period in all the three types of cements. On the average the flexural strengths increases by 32% at 28 days for all the types. It can also be observed that the flexural strength is higher with cement grade 42.5.

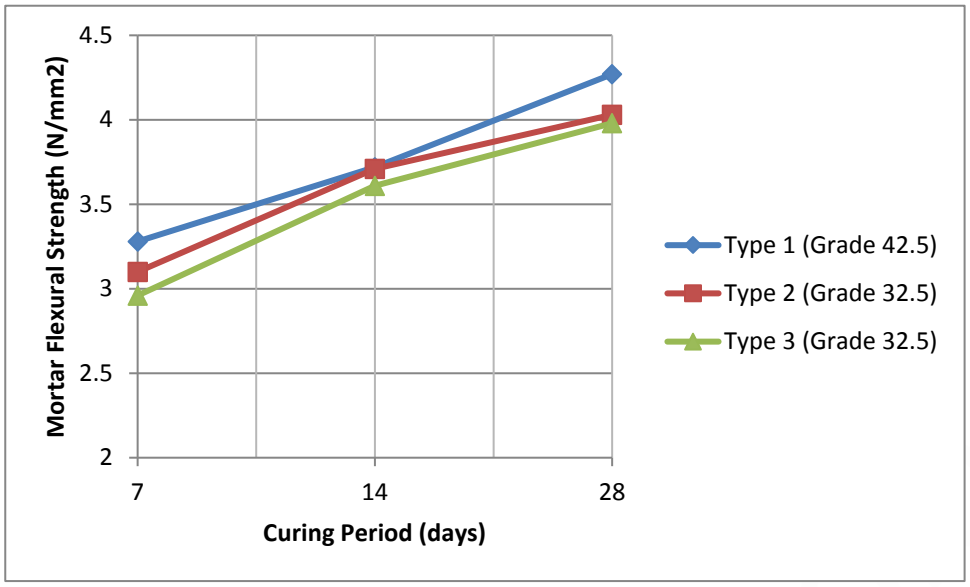

Figure 2 Effect of cement grade on Mortar flexural strength

3.3. Mortar Compressive Strength

Results of the mortar compressive strength test presented in Figure 3 shows that Grade 42.5 cement produced mortar with higher compressive strength than that of Grade 32.5.

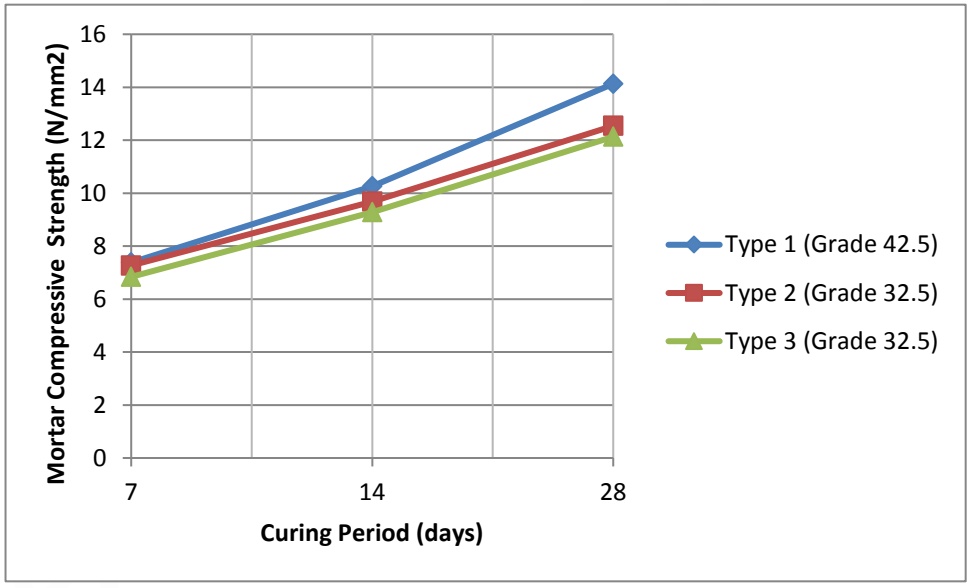

Figure 3 Effect of cement grade on Mortar compressive strength

The mortar compressive strength increases with curing period as shown in the Figure. Considering 28 days compressive strength result, Type 1 (Grade 42.5) has compressive strength of 14.13 N/mm^2 while Type 2 (Grade 32.5) and Type 3 (Grade 32.5) have compressive strengths of 12.54 N/mm^2 and 12.13 N/mm^2 respectively. The compressive strength values for the Grade 32.5 are within mortar designation type (i), class M12of BS5628 (BS5628-1:, 2005). However, cement Grade 42.5 has strength much higher than that required by the code; this implies that in terms of compressive strength, Grade 32.5 cements are more suitable as mortar. This is because Mortars that are stronger than the units they are bonding can result in cracking of the units (MIA, 2013).

3.4. Mortar Drying Shrinkage

The results of the mortar drying shrinkage as shown in Figure 4, shows that Cement Grade 42.5 exhibit higher drying shrinkage than that of Grade 32.5. Stronger mortars with higher cement contents tend to have higher shrinkage. This may result in an increased risk of rain penetration due to the greater potential incidence of fine crack formation.

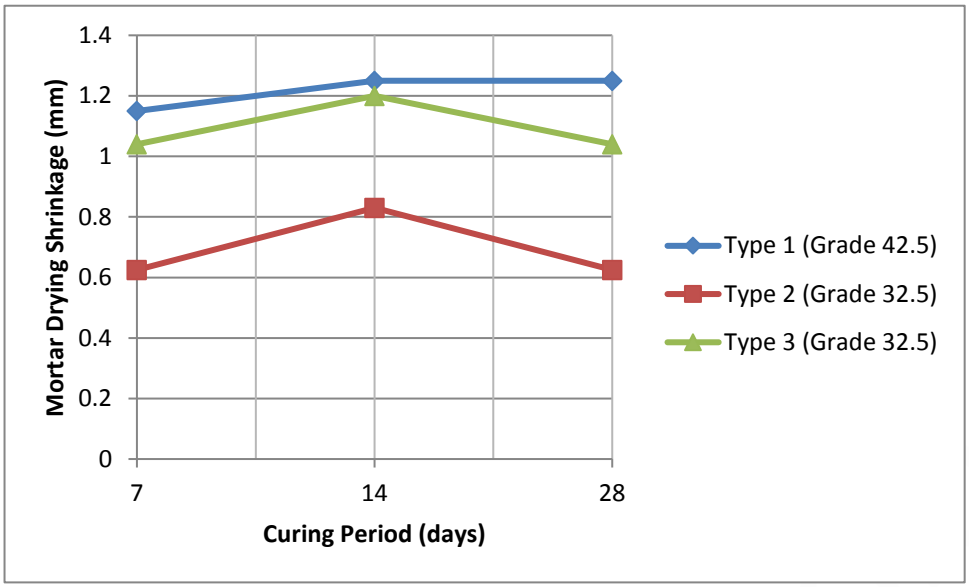

Figure 4 Effect of cement grade on Mortar drying shrinkage

4. CONCLUSION

The flexural strength, compressive strength and drying shrinkage are higher in cement Grade 42.5 than in cement Grade 32.5. Even though, higher strengths are advantage in concrete, mortar is not supposed to have strength stronger than the units it is bonding. Therefore, based on the experimental results obtained, it can be concluded that cement Grade 32.5 is more suitable for use as mortar than Grade 42.5, as it will have more ability to accommodate movement, e.g. due to settlement and moisture changes.

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