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Effects of maximum size of brick aggregate on properties of concrete

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HIGHLIGHTS

- Effects of maximum aggregate size (MAS) on brick aggregate concrete was studied.
- MAS was varied from 12.5 to 50.0 mm; cement contents from 375 to 400 kg/m^3.
- Sand to total aggregate ratio was varied from 0.40 to 0.45; W/C from 0.45 to 0.55.
- Concrete compressive strength increases for lower MAS for a higher cement content.
- Compressive strength is increased up to MAS of 35 mm for lower cement content.

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ABSTRACT

Effects of maximum aggregate size (12.5 mm, 19.0 mm, 25.0 mm, 37.5 mm, and 50.0 mm) on properties of concrete made with different sand to total aggregate volume ratio (0.40 and 0.45), W/C ratio (0.45, 0.50, and 0.55), and cement content (375 kg/m^3 and 400 kg/m^3) were investigated. Considering the variables, a total of 552 concrete cylinder specimens of diameter 100 mm diameter and height 200 mm were made for 52 numbers of independent cases. Brick aggregates were tested for specific gravity, absorption capacity, unit weight, and abrasion resistance. Concrete specimens were tested for compressive strength, stress-strain curve, splitting tensile strength, and Young's modulus. Results have revealed that for higher cement content (400 kg/m^3), concrete made with small aggregates give more compressive strength. However, for a cement content of 375 kg/m^3, and W/C ratio of 0.45, the compressive strength is increased with an increase in maximum aggregate size up to 37.5 mm. The compressive strength of concrete increases with an increase in s/a ratio from 0.40 to 0.45. Relationships between mechanical properties of concrete, and stress-strain relationships are proposed for different maximum aggregate sizes.

1. Introduction

Concrete is a widely used construction material having 75% of the volume occupied by aggregate, of which, 45% is coarse aggregate [1]. For this reason, aggregate properties are likely to affect the durability and structural performance of concrete. Aggregate properties, such as mineralogy, surface area, texture, particle size and shape, elastic modulus, toughness, soundness, strength, grading, and water absorption have been reported to have a significant effect on the performance of concrete [2–6]. Moreover, physical and mechanical properties of coarse aggregate, including maximum aggregate size (MAS) can affect properties of fresh and hardened concrete. Early researchers like Walker and Bloem [7], Bloem and Gaynor [8] concluded that an increase in aggregate size from 10 mm to 64 mm results in a decrease in the compressive strength of concrete, by as much as 10%, however, aggregate size seems to have negligible effects on flexural strength. Aitcin [9] concluded that increase in the MAS up to 25 mm leads to better workability, but produces larger and heterogeneous Interfacial Transition Zone (ITZ), which may compromise the quality of concrete. On the contrary, Vu et al. [10] suggested that the concrete strength slightly increases as the coarse aggregate size increases as observed under unconfined compression. Moreover, the fracture energy of concrete has been reported to increase with an increase in MAS [11]. Ezeldin and Aïtcin [12] concluded that normal-strength concrete is not greatly affected by the type or size of coarse aggregates. These aforementioned contradictions in literature may be due to the

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differences in mixture proportions, and must be studied by varying mixture proportion parameters like cement content, sand to total aggregate volume (s/a) ratio, water to cement (W/C) ratio, etc.

In Bangladesh, crushed brick aggregate is the most commonly used coarse aggregate in making concrete [13–15]. Brick aggregates are made by crushing clay-burnt bricks mechanically or by

Table 1
Gradation of coarse aggregate (According to ASTM C 33 [20]).

Nominal size	Amounts finer than each laboratory sieve, Mass percent						
	50.0 mm	37.5 mm	25.0 mm	19.0 mm	12.5 mm	9.5 mm	4.75 mm
50.0 to 25.0 mm	95	50	10	–	0	–	–
37.5 to 12.5 mm	–	90	40	10	–	0	–
25.0 to 9.5 mm	–	100	90	50	15	0	0
19.0 to 4.75 mm	–	–	100	90	40	10	0
12.5 to 4.75 mm	–	–	–	100	90	50	0

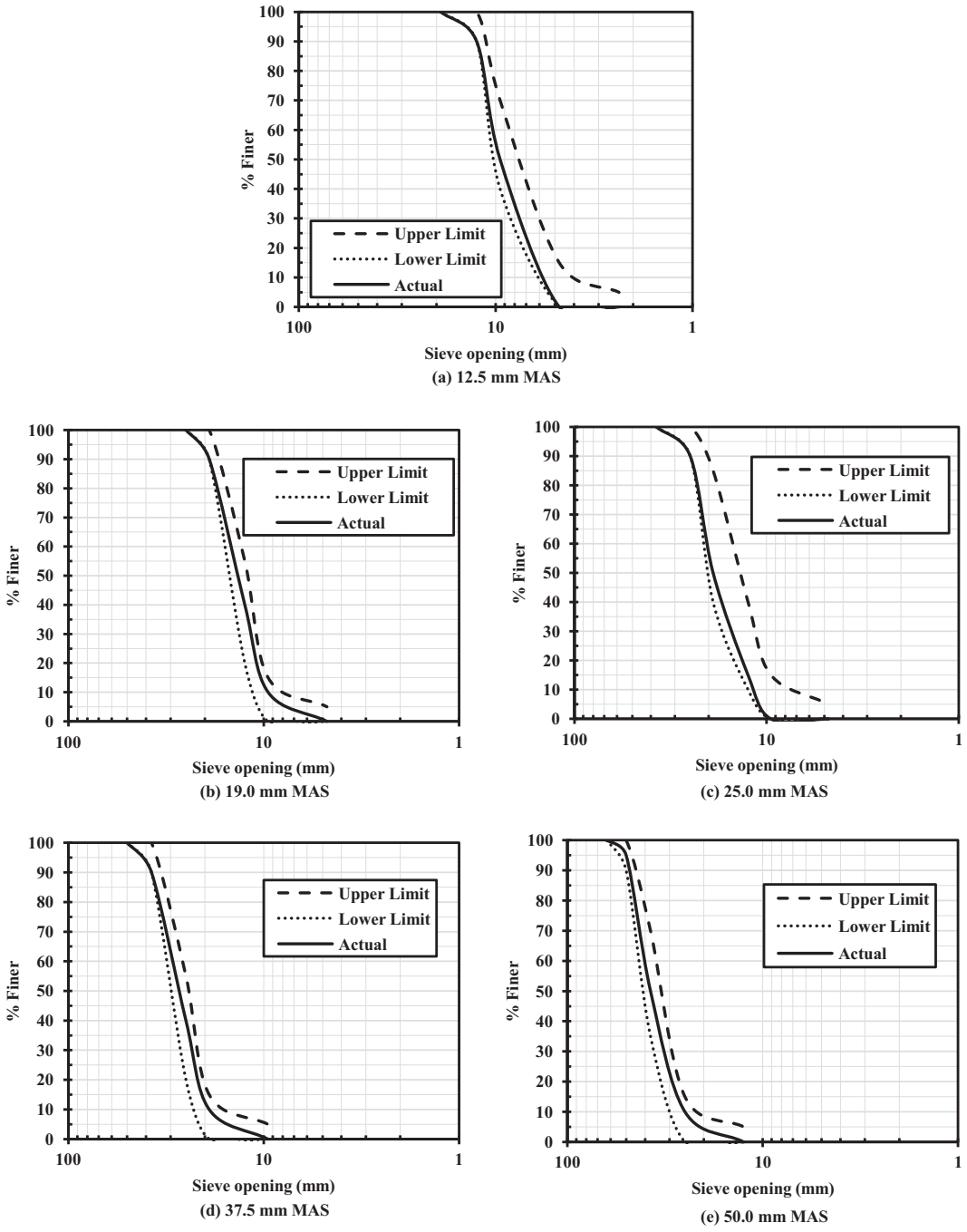

Fig. 1. Gradation of coarse aggregate.