

Optimizing High-Strength Concrete for Enhanced Structural Performance

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ABSTRACT

Concrete has been since a long time a major material for providing a stable and reliable infrastructure. Concrete with compressive strengths of 20-40N/mm² have been traditionally used in construction projects. With the demand for more sophisticated structural forms along with deterioration, long term poor performance of a conventional concrete led to accelerated research for development of concrete which would score on all the aspects that a new material is evaluated upon i.e. workability, durability, affordability and thus enable the construction of sustainable and economic buildings with an extra ordinary slim designs besides providing material that will have long term better performance and reduced maintenance. The development of High Strength Concrete has been a great breakthrough in Concrete Technology. High strength concrete (HSC) may be defined as concrete with a specified characteristic cube strength between 40 and 100 N/mm², although higher strengths have been achieved and used. Strength levels of 80 to 100 N/mm² and even higher are being used for both precast and in-situ works. High Strength Concrete is specified where reduced weight is important or where architectural considerations require smaller load carrying elements. The use of high strength concrete offers numerous advantages in the sustainable and economical design of structures.

KEYWORDS: ssc, HSC, CONPLAST SP430,

INTRODUCTION

The development of High Strength Concrete is based on the water-binder ratio. For high strength/c ratio should be low. Low W/C ratio is required for low permeability of concrete, which is vital for high durability. Impermeability is also aided by pour filling action of fine pozzolanic additions. The relationship between coefficient of permeability of cement paste and W/C ratio is such that the permeability increases asymptotically for W/C ratio above 0.45 or so. Thus, low water-cement ratio will require high cement content to ensure that the amount of water and cement paste are adequate for the workability of concrete. However too high a cement content will cause a large heat of hydration and increase cracking tendency. Hence, a part of cement is to be replaced by other cementitious materials like silica fume, fly ash or ground granulated blast furnace slag or combinations thereof. Use of low water-cement ratio and other cementitious materials makes the use of super plasticizers mandatory. Thus, the composition of High Strength Concrete is of chosen quantities of cement, aggregates, water, super plasticizers, silica fume or fly ash or slag.

SCOPE OF HIGH STRENGTH CONCRETE

High Strength Concrete is required in engineering projects that have concrete components that must resist high compressive loads. HSC is typically used in the erection of high rise structures. It has been used in components such as columns (especially on lower floors where the loads will be greater, shear walls and foundations. High strengths are also occasionally used in bridge applications as well. In high rise structures, high strength concrete has been successfully used in many countries across the globe. High Strength Concrete is occasionally used in the construction of highway bridges. HSC also permits reinforced or prestressed concrete girders to span greater lengths than normal strength concrete girders. High Strength Concrete enables to build the super structures of long span bridges and to enhance the durability of bridge decks. Other structural members in which High Strength Concrete is used are dams, grand stand roofs, marine foundations, heavy duty industrial floors and parking garages.

CONCEPTS IN THE DESIGN OF HIGH STRENGTH CONCRETE

In order to achieve High Strength Concrete, various important factors that govern the strength of concrete are to be understood. They are:

- Properties of cement paste
- Properties of aggregate
- Various chemical and mineral admixtures to used
- Properties of the admixtures used
- Proportions of the constituents to be used
- Paste-Aggregate reaction
- Mixing, Compaction and Curing
- Testing procedures

CHARACTERISTICS OF HIGH STRENGTH CONCRETE

The key elements of HSC can be summarized as follows:

- Low water-binder ratio(ranges from 2.5 to 3.5)
- Use of mineral admixtures like Silica Fume, Meta Kaolin, Fly Ash etc.
- Small aggregates (12.5 mm and 10 mm) and fine sand
- High dosage of super plasticizers
- Heat treatment and application of pressure at curing stage
(Applicable for Ultra High Strength Concrete)

ADVANTAGES OF HIGH STRENGTH CONCRETE

The advantages of using High Strength Concrete have been described in various researches. These include

- Reduction in member size
- Reduction in the self-weight and super imposed dead load with the accompanying saving due to smaller foundations
- Reduction in form work area and cost
- Longer spans and fewer beams for the same magnitude of loading,
- Reduced axial shortening of compression members
- Reduction in the number of supports and the supporting foundations due to increase in spans
- Reduction in thickness floor slabs and supporting beam sections which are a major component of the weight and cost of the majority of structures
- Superior long term service performance under static, dynamic and fatigue loading
- Low creep and shrinkage

TESTS ON CEMENT:

- Fineness
- Normal consistency
- Initial and final setting time
- Specific gravity

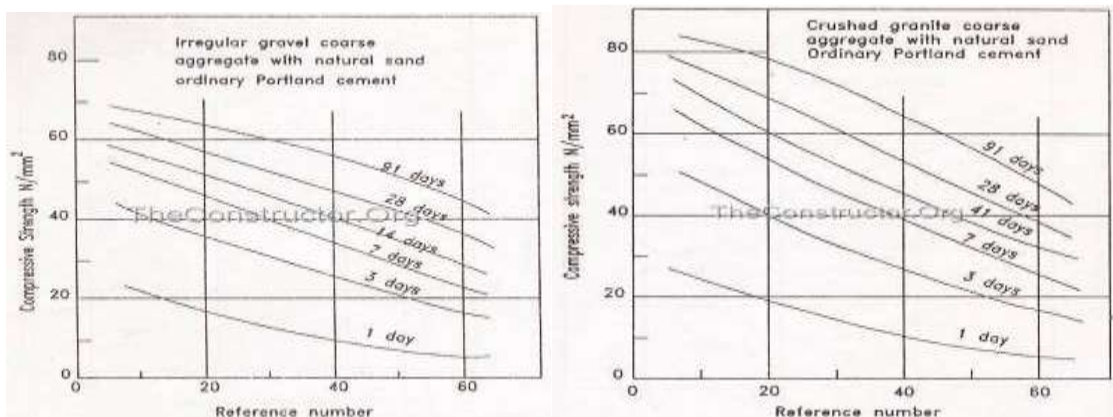
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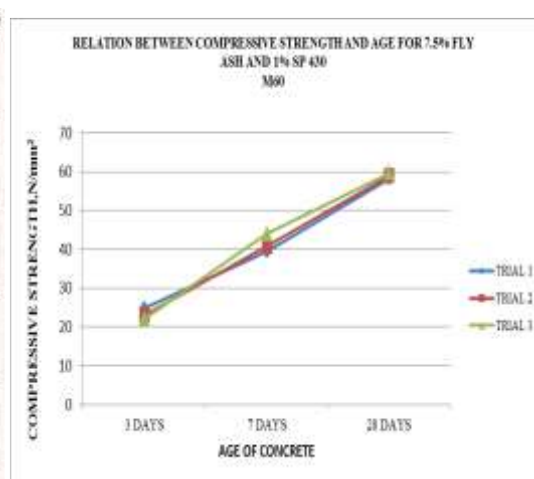
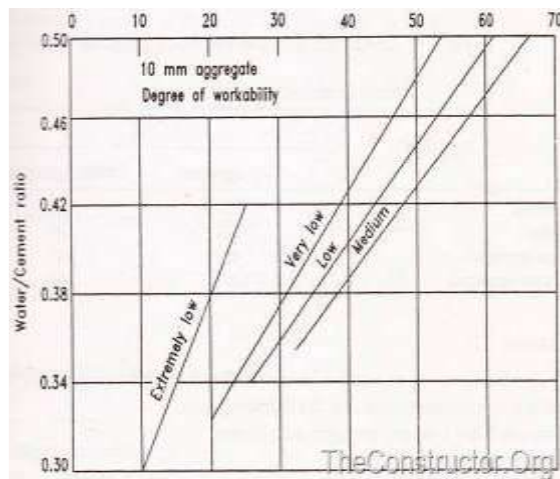
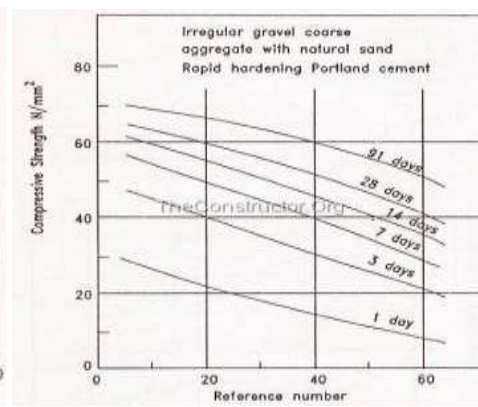
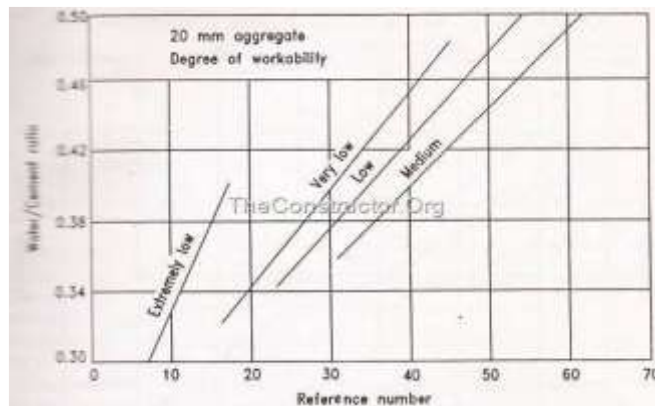
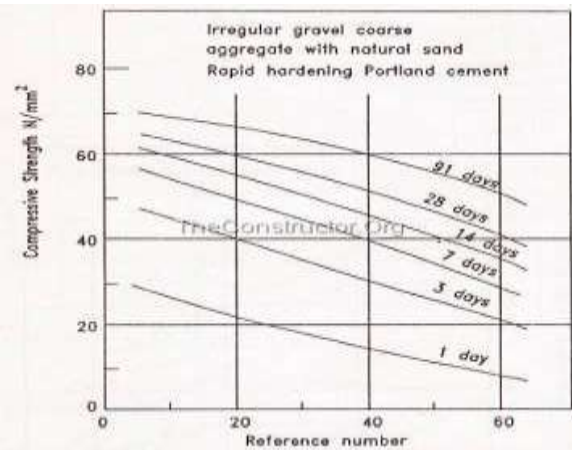
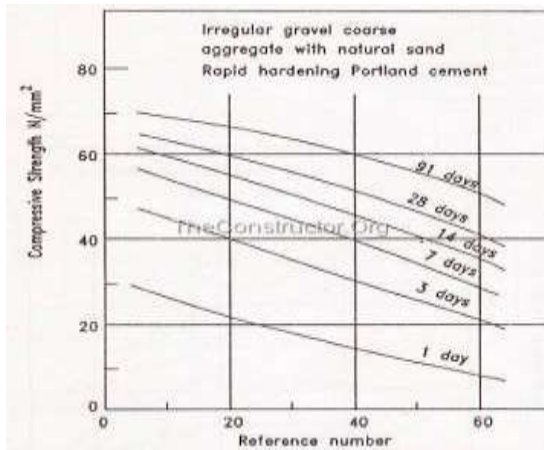
- Fineness modulus
- Aggregate impact test
- Aggregate crushing test
- Specific gravity

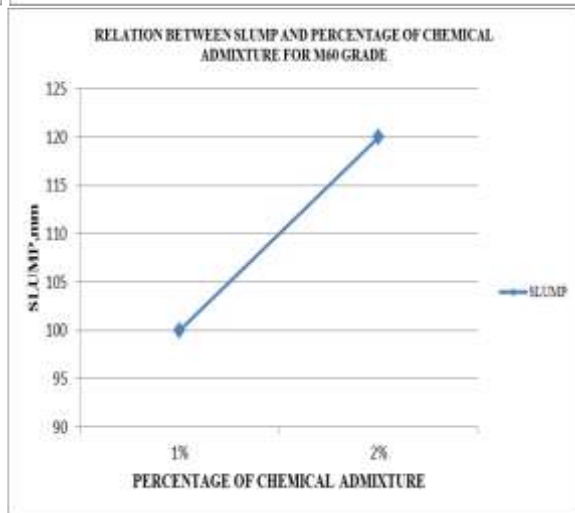
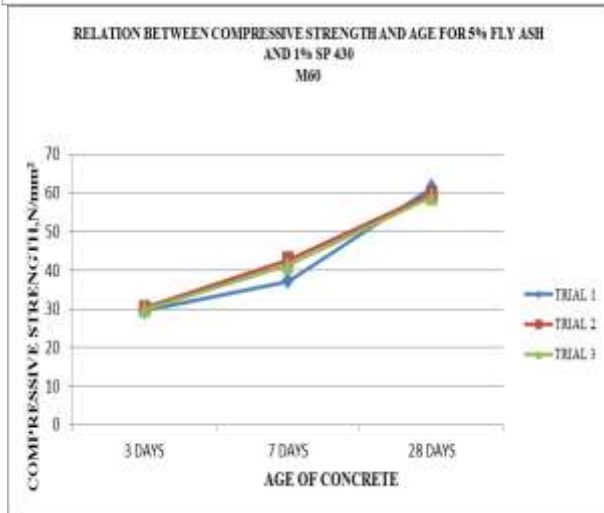
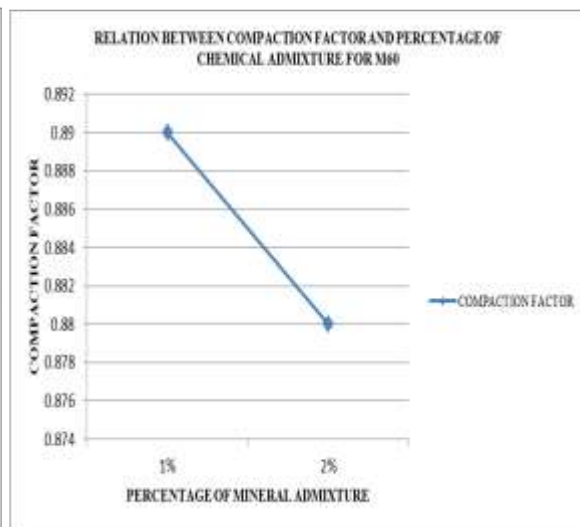
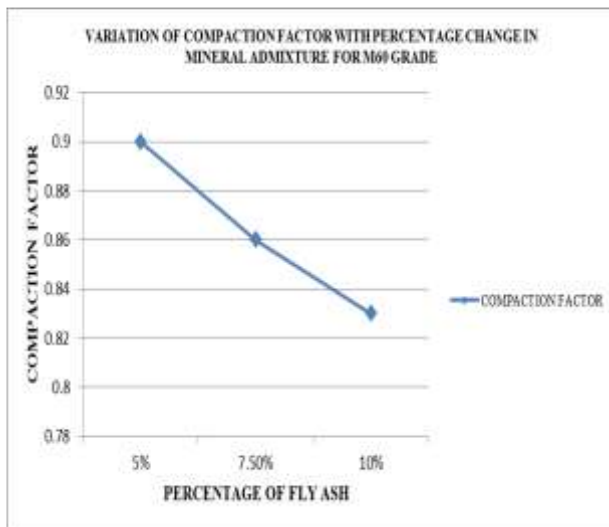
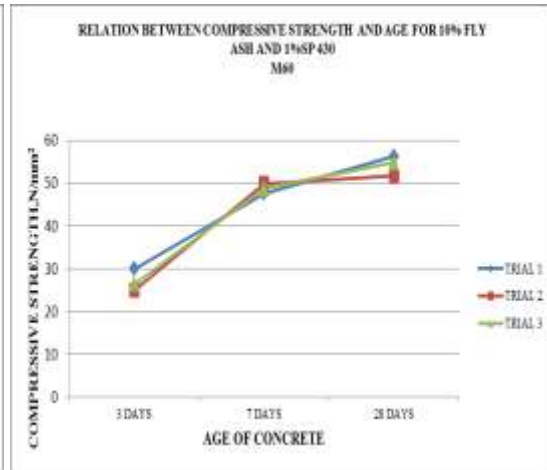
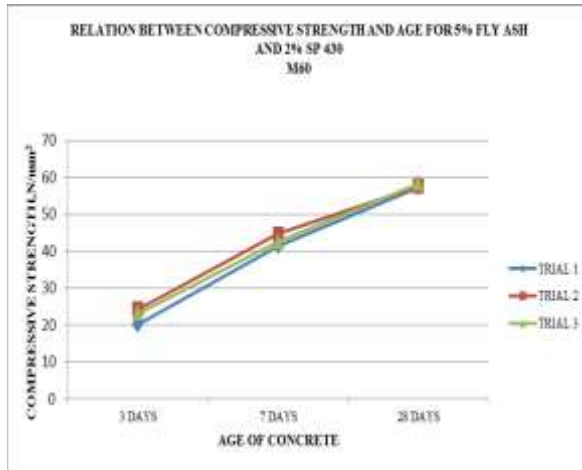
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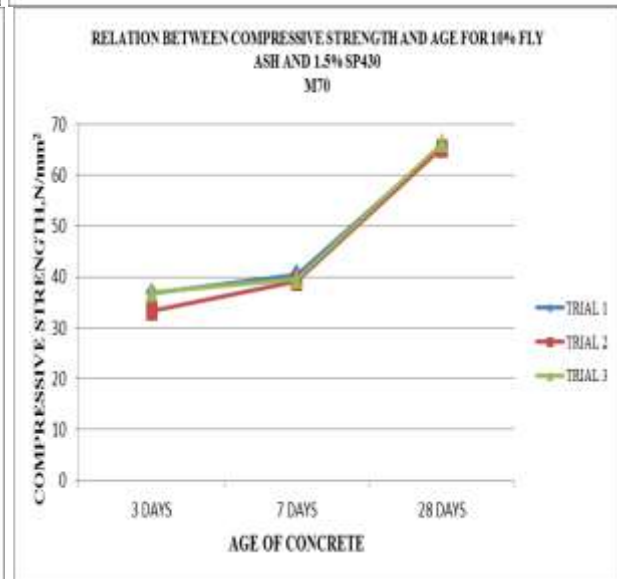
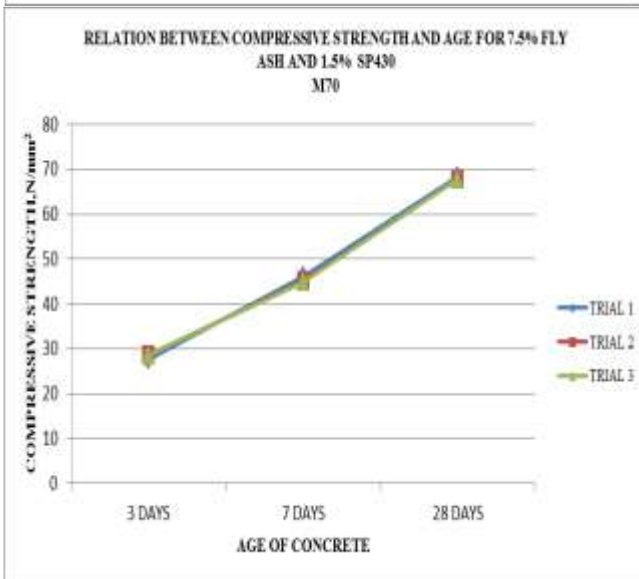
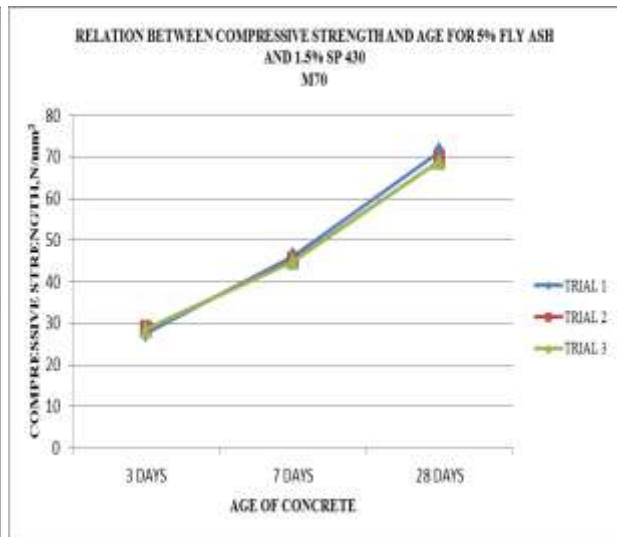
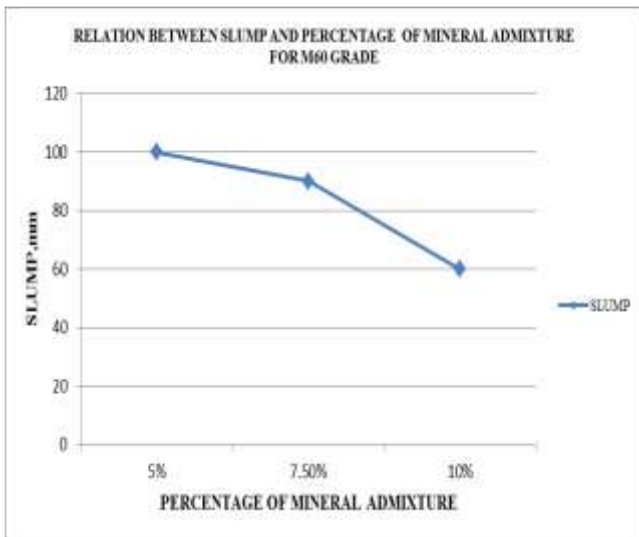
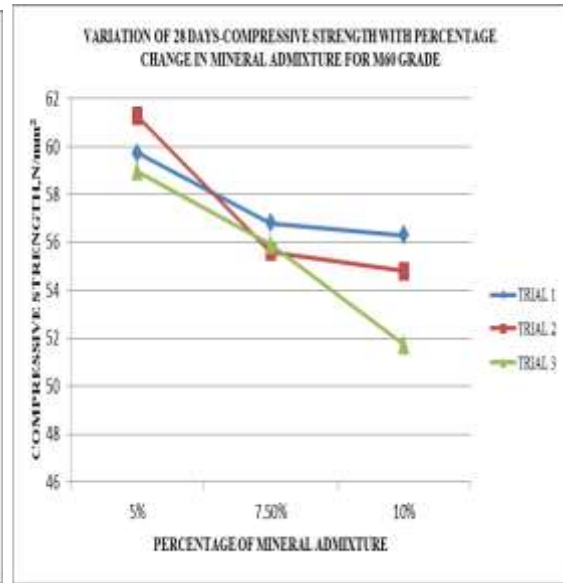
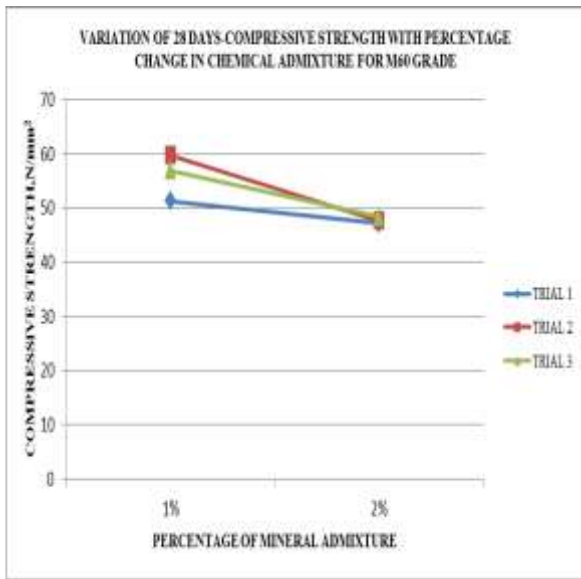
- Fineness modulus
- Specific gravity

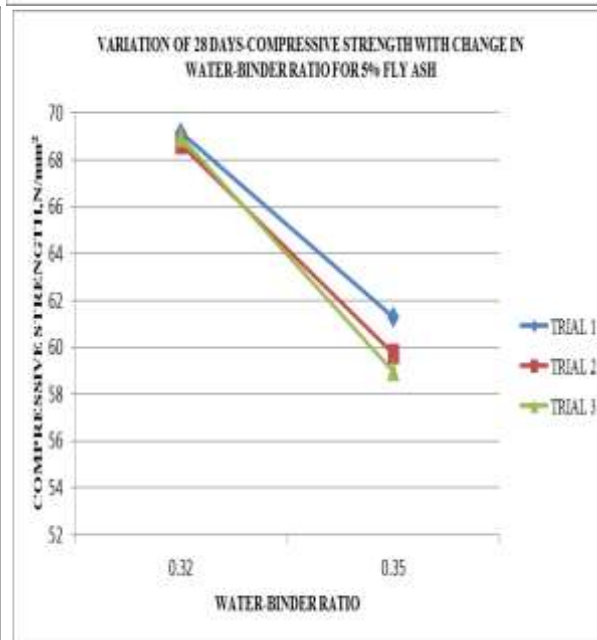
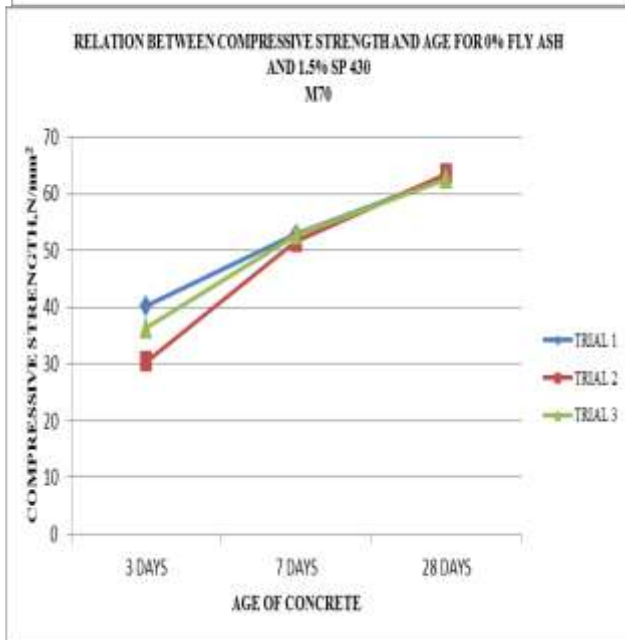
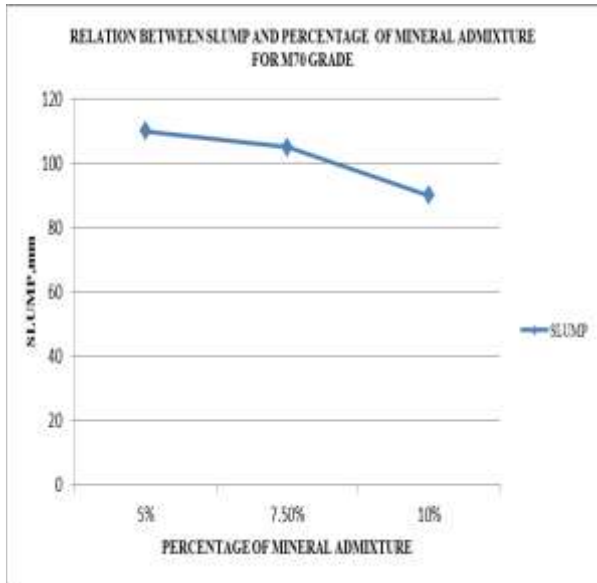
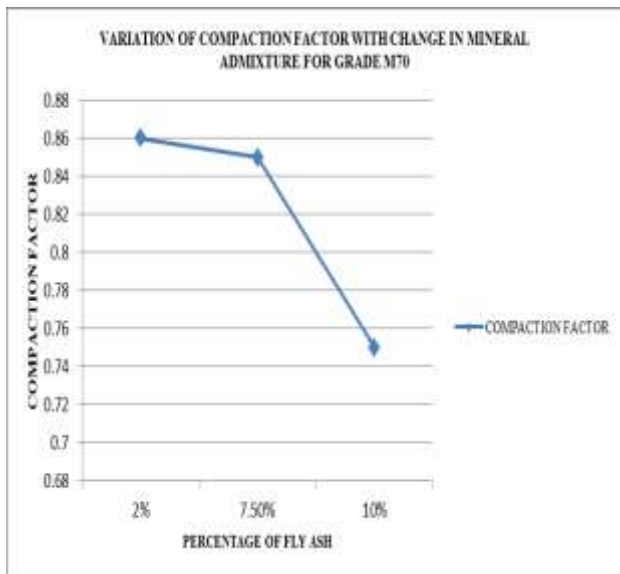
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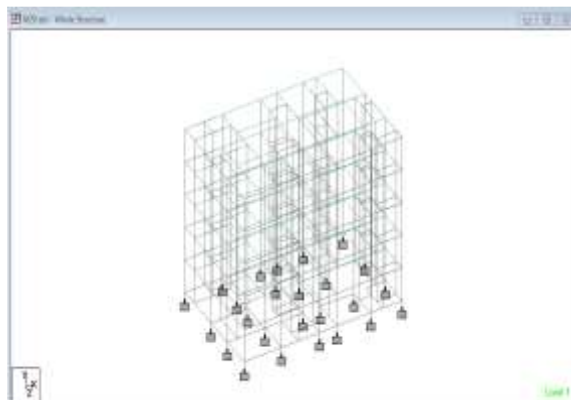
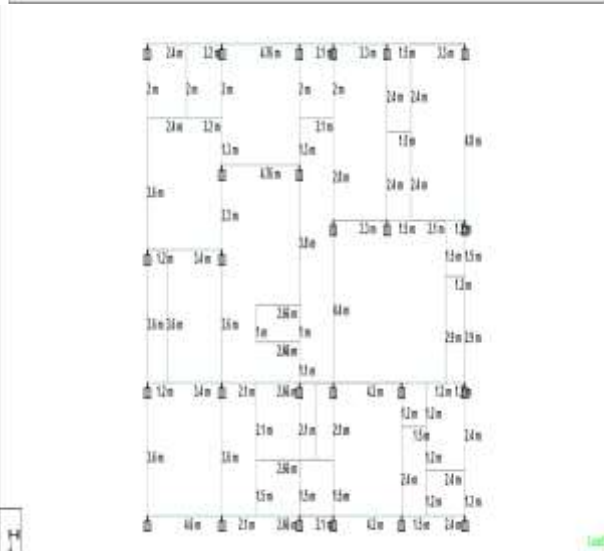
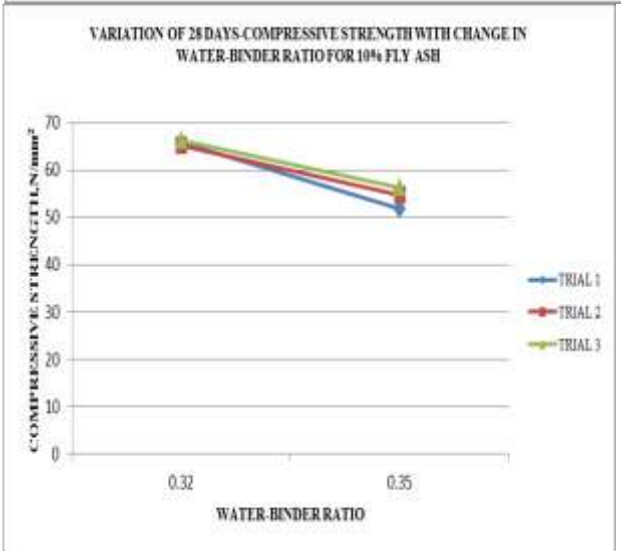
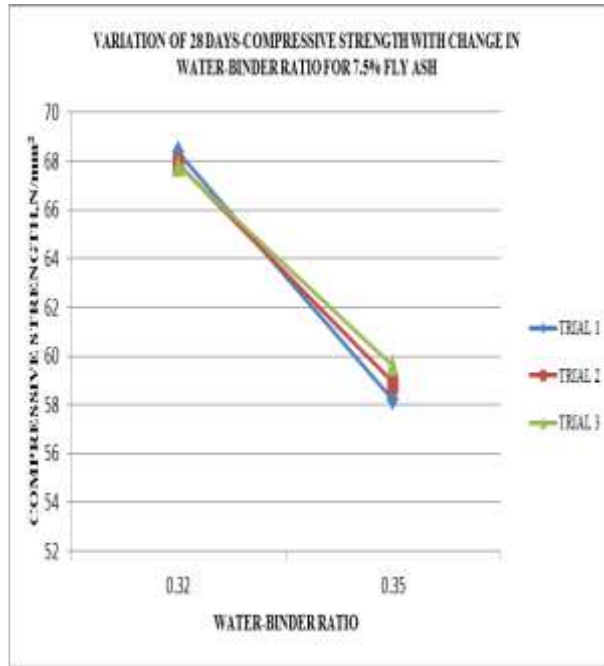
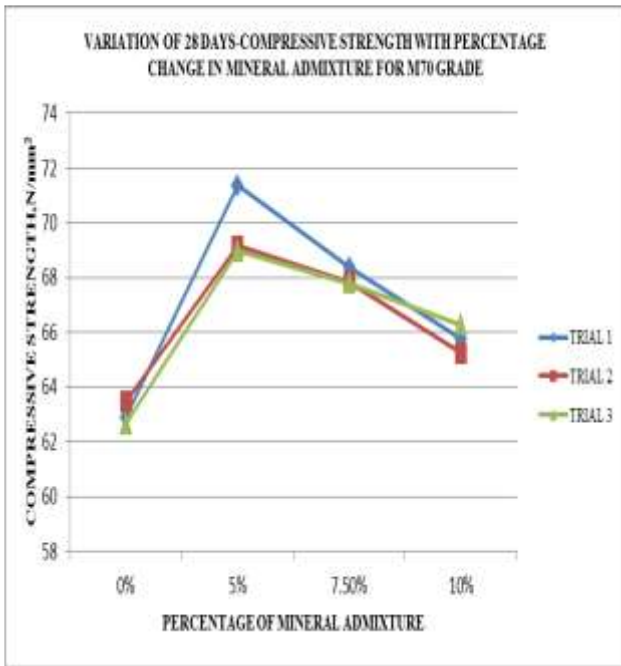


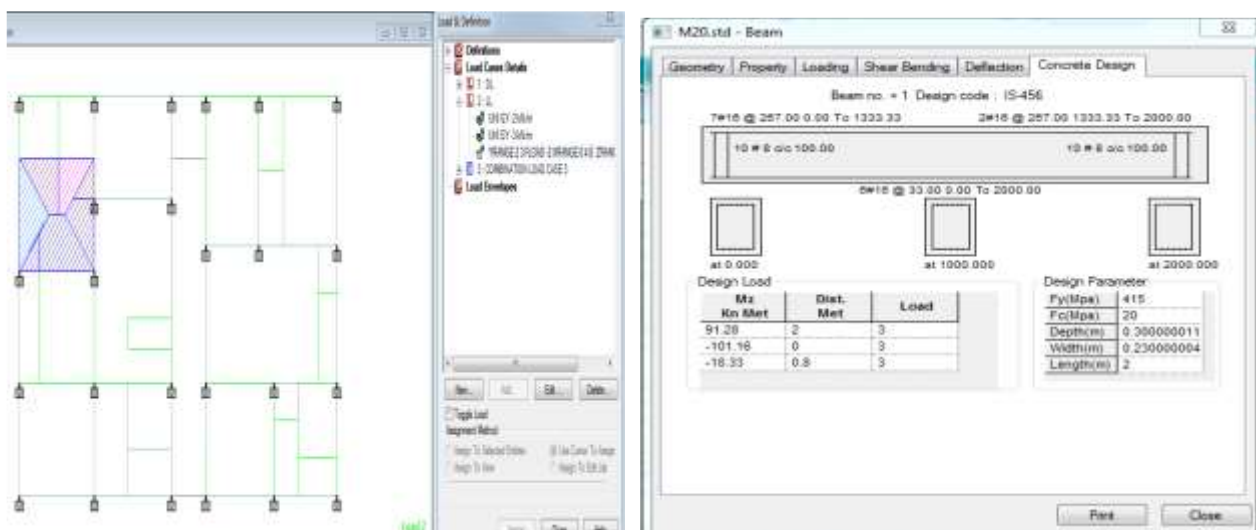
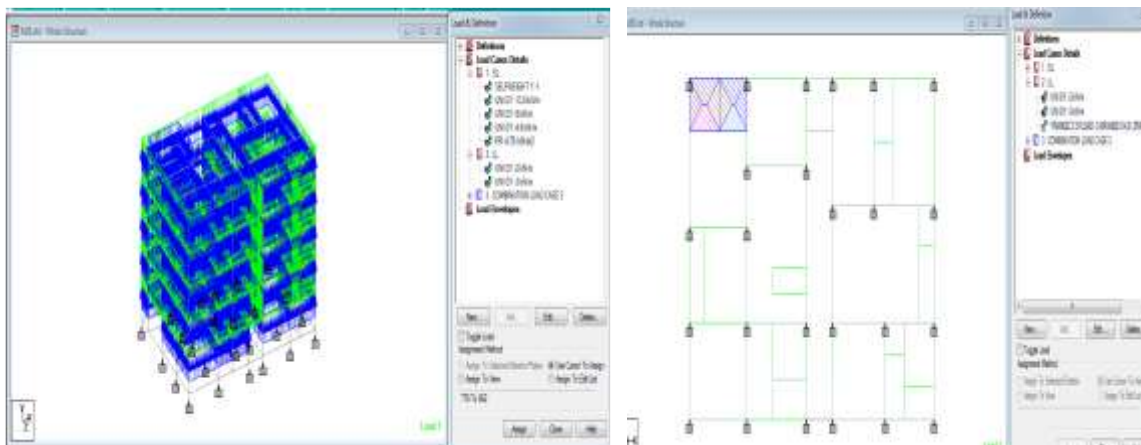
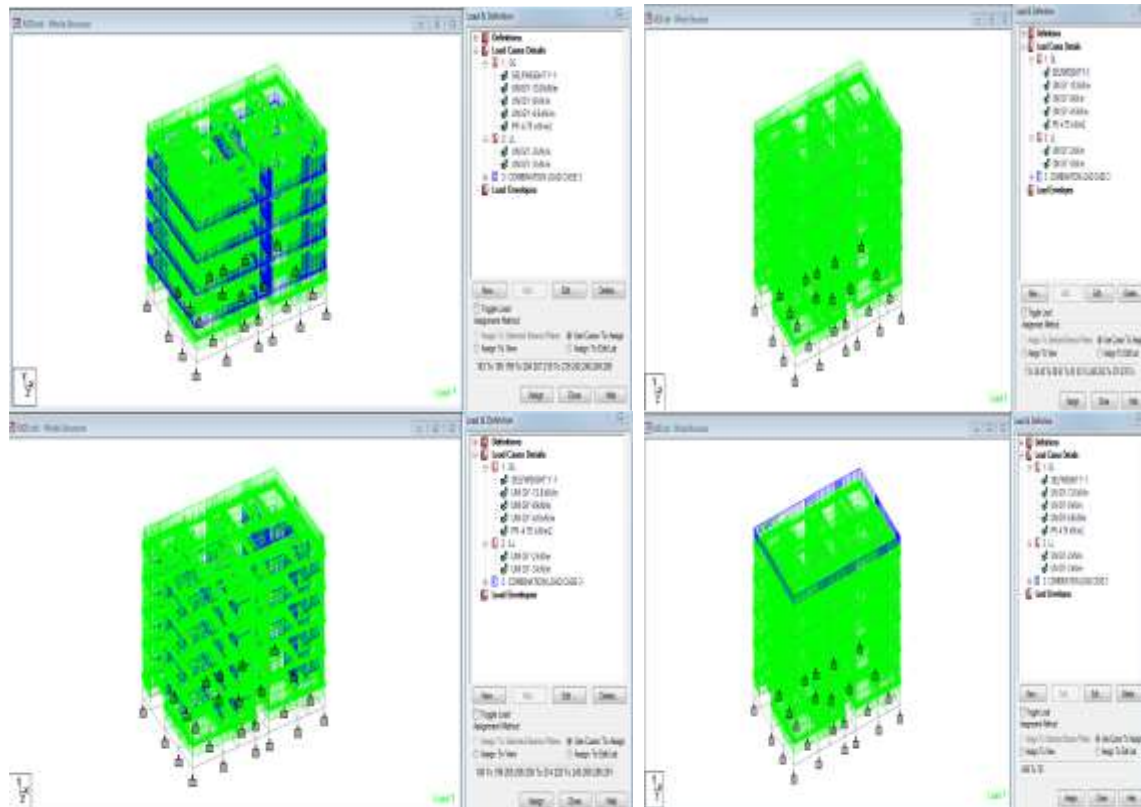


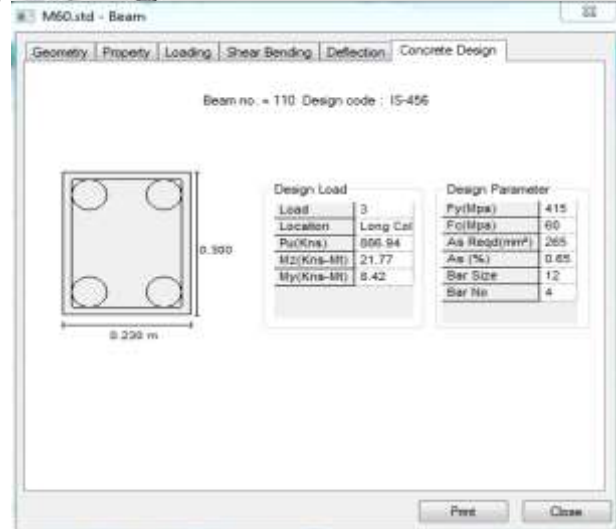
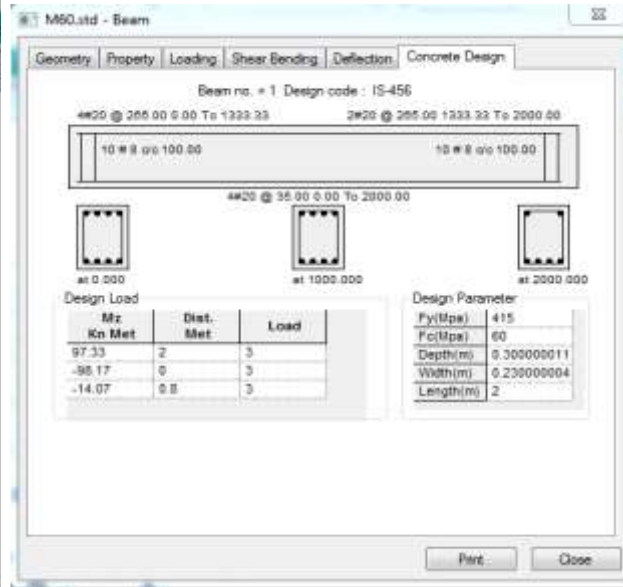
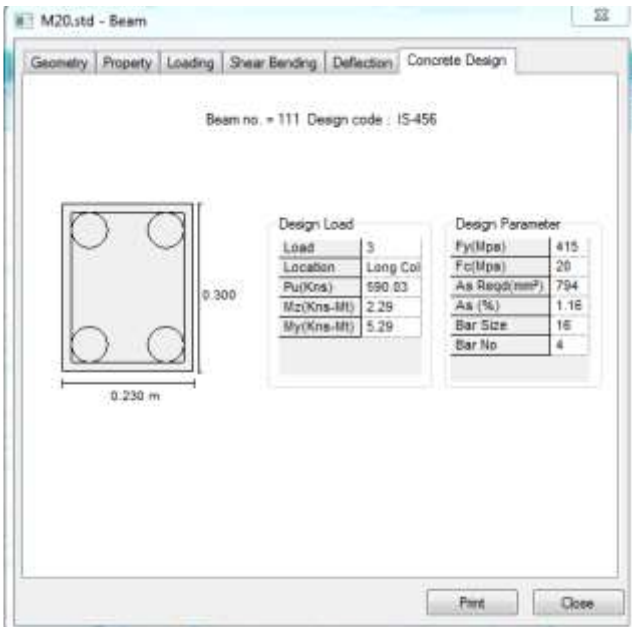
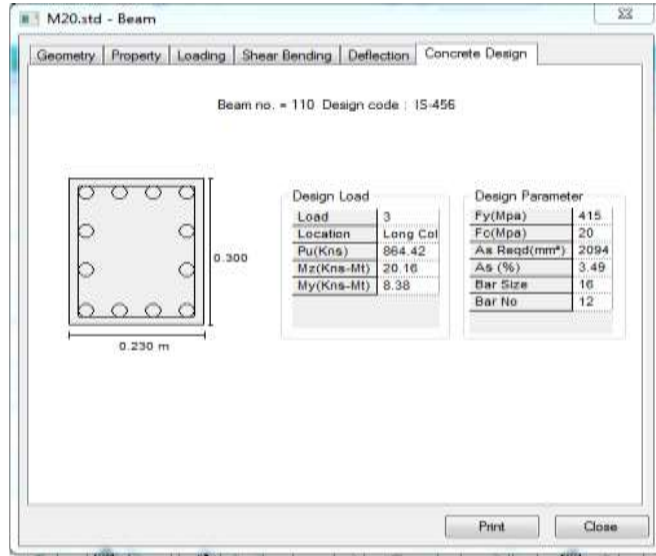
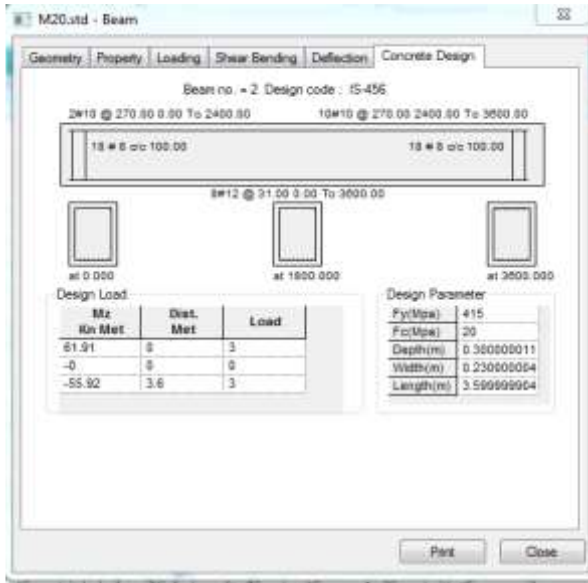


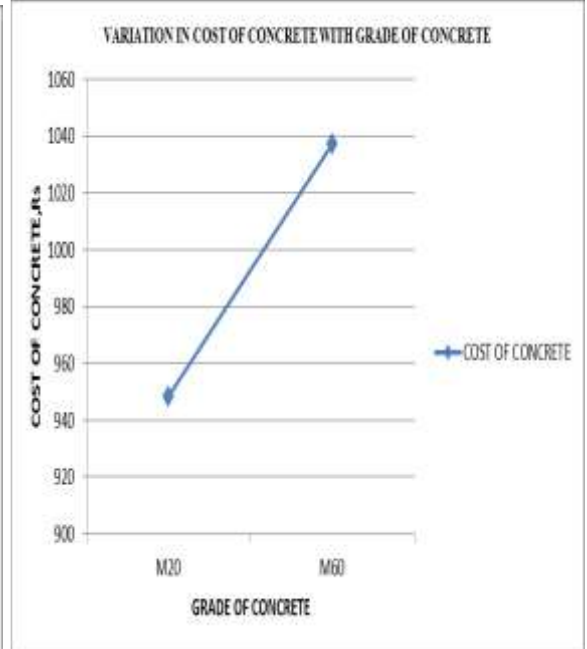
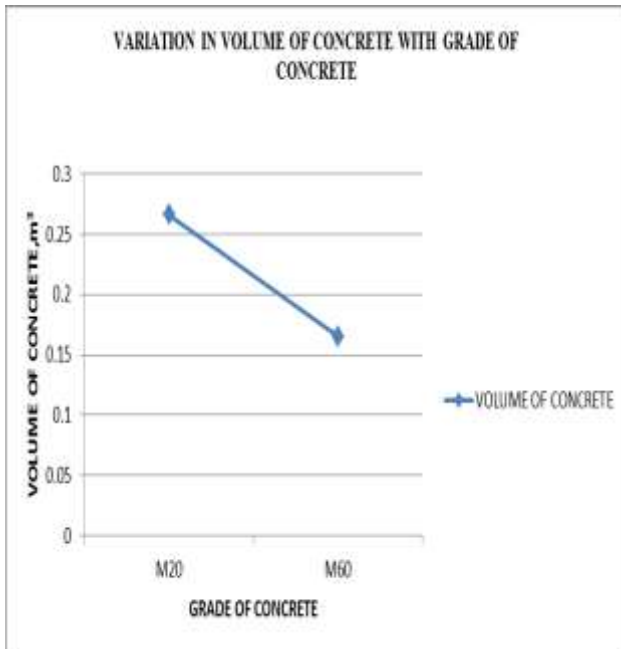
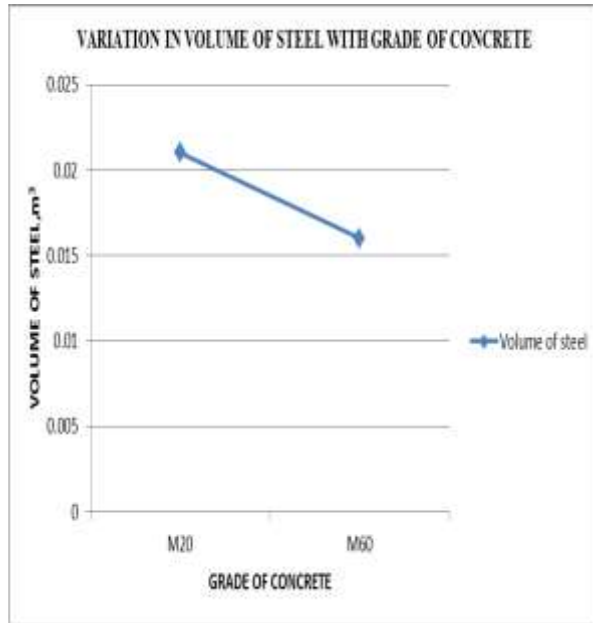
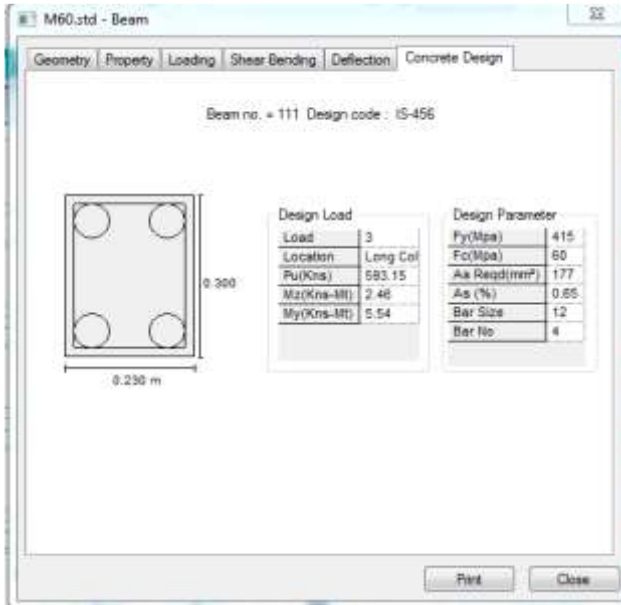


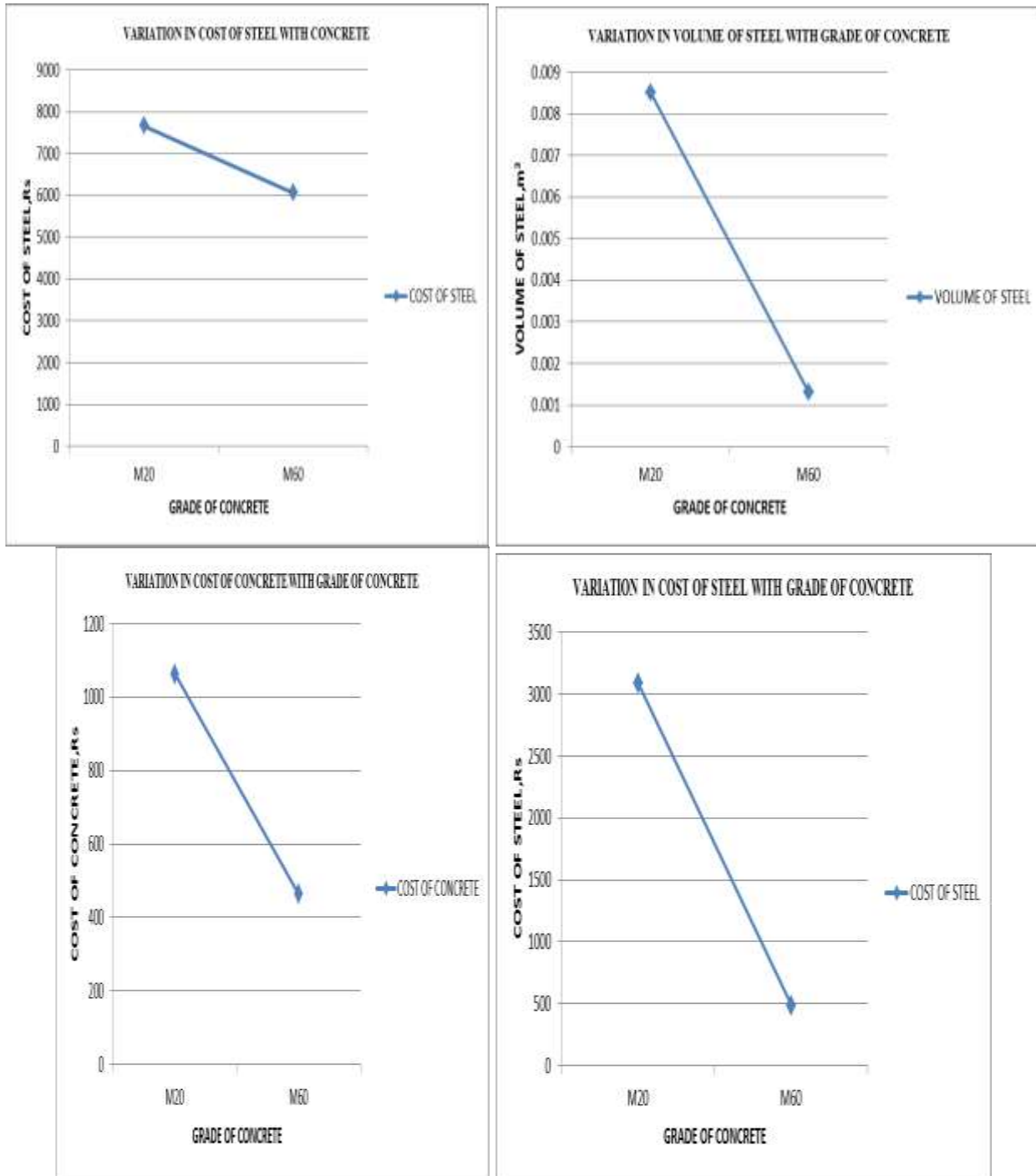












EARLIER RESEARCHES

Some of the earlier researches on the effectiveness in designing of structures like high rise buildings with High Strength Concrete are as follows:

- a) S.C.MAITI, RAJ.K.AGARWAL and RAJEEB KUMAR(The Indian Concrete Journal December 2006) gave relationships between water-cement ratios or water-binder ratios and 28-day compressive strength for concrete containing OPC or PPC or PSC or (OPC+FLY ASH) or (OPC+GGBS) and super plasticizer based on the data from different construction sites and gave a critical observation that these relationships are almost the same as given in IS 10262 for two grades of OPC (43 grade and 53grade).Regarding sand and water contents, suggestions to modify the existing guide lines of IS 10262 have also been given for super plasticized concrete mixes.
- b) J.HEGGER (Aachen University of Technology, Institute of Concrete Structures, 52056 Aachen, Germany) studied the economical and constructional advantages of High Strength Concrete for a 186 m high rise building in Frankfurt, Germany concluded that, for columns designed for 20KN with 85MPa concrete more than 50% of the reinforcement can be saved when

compared to 45MPa concrete. In spite of the approximately 60% higher concrete cost the total cost of the building can be reduced by about 15%.

CONCLUSIONS

From the above tables and graphs, we can conclude that:

For Beams,

The volume of steel decreased with increase in grade of concrete.

The volume of concrete for members increased with increase in grade of concrete.

The cost of concrete increased with increase in grade of concrete.

The cost of steel decreased with increase in grade of concrete.

On a whole, the cost of reinforced cement concrete is less for M60 grade concrete when compared to M20 grade concrete.

For columns,

The volume of steel decreased with increase in grade of concrete.

The volume of concrete for members also decreased with increase in grade of concrete.

The cost of concrete decreased with increase in grade of concrete.

The cost of steel decreased with increase in grade of concrete.

On a whole, the cost of reinforced cement concrete is less for M60 grade concrete when compared to M20 grade concrete.

Therefore we can conclude that High strength concrete is cost effective as well as durable when compared to normal strength concrete.