

Concrete elastic modulus for various aggregate types construction essay



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Concrete generally, is an inevitable constructional material in civil Engineering for profitability and economy of designs in life. Therefore, much emphasis must be placed on the efficacy for sustainability of the people to avoid risk of progressive collapse due to the instability of its nature after design. It is a challenge to curb the menace of inadequacy of design for the durability of concrete all day. The heterogeneity of concrete is real to be composed of Cement, Water (uncontaminated), Fine and Coarse aggregates otherwise known as constituent materials. The fossils lie embedded in a matrix of cement, water, fine and coarse aggregates and, are so strong because of the binding ability of the properties, absorbency in nature and most importantly, skilful knowledge of the designers during construction. The volume of concrete occupied by the coarse aggregates is significantly great compared to other properties thereby, playing the biggest role in terms of given desired strength recommended by different professional associations in the world. Concrete also is made up high compressive strength and a low value of tensile strength. It is used to protect corrosion of steel reinforcing bars.

The importance to investigate concrete Elastic Modulus for various aggregate types as a parameter which enhances deformation resulting to cracks during serviceability with time is a course that cannot be undermined in the study of concrete properties. This implies that Elastic Modulus is a property that depends on compressive strength and aggregates stiffness. Strength and Stiffness are termed as the most probable important of all the properties of concrete materials considered for suitable structures design. The strength of a material obviously controls the estimation of the collapse

load of a structure. Stiffness is important to ensuring un-deflection too much under load as well as dominates the avoidance of buckling of compression members.

The characteristic strength of concrete is said to be classified based on designated concrete called strength class that depends on the types of constructions to be executed. When the value of compressive strength is too high there is a probability that most of the structures will be constructed of concrete possessing strength below this value and, too low a value will cause inefficient use of materials. So, it is the characteristic strength value of the cube strength at 28 days below which not more than 5% of the test outcomes may be expected to depreciate is the primary concern of every designer at every point in time.

The British Standards BS8110 indentifies the clause: "The Strength, below which, not more than 5% of specimen will fail" to signify strength that is very close to the mean value of a large samples of concrete normally distributed in a Bell-shaped against the frequency. This is idealized that some samples of concrete are stronger while others are weaker in strength and these variations are measure of the standard deviation.

1. 20. PROPERTIES OF CONCRETE IN COMPRESSION

The properties of concrete in compression are attributed to Short-term and Long-term loadings when discussing the linearity and un-linearity of the stress-strain curve. Short-term loading is used for Normal weight or density concrete and represented the most linear part called the elastic region of the

stress-strain curve. The curve defines the uniaxial compressive test performed at normal, average speed on concrete at 28 days. The straight elastic portion describes how stress and strain are closely related before maximum stress is effective. Modulus of Elasticity is a derivative parameter resulting from the slope of this linear portion of the curve and is always larger in value when the strength of the concrete increases. The stress-strain curve shape varies considerably for identical concrete of the same cylindrical strength under the same loading condition and this strange behaviour depicts the variability in concrete samples due to one factor or the other from testing procedures: Nilson, Darwin and Dolon (2004: 40).

Long-term loading is the creeping nature of concrete with time. This is the continuous loading of concrete beyond 28 days of aged. The deformations of concrete are practically observed at this point in time which are proportional to the magnitude of the stress. At this region on the stress-strain curve, the stress is not longer linear. In addition to the load level, creep depends on the average humidity which is an important parameter to be investigated when designing a concrete.

1. 30. THE REVIEW OF OTHER WORKS

Based on the review of others, the Magazine of concrete Research(1991), Kaplan revealed that concrete with the same compressive strength may have different dynamic modulus of elasticity of different aggregates. The British Standard Institute CP110, and European Code; model code for concrete structures whereas made no provision but grossly looked at estimating compressive strength only. ACI Code tried in its little way to

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include a term for concrete density the expression for elastic modulus, since this term is raised to the power of 1.5, it has considerable weighting. But the BS110 has provided bases to satisfy new expressions for estimating the elastic modulus based on the work of Teychenne, to conform to the Stress-strain relationship of concrete such that:

$$E_{c28} = K_o + 0.2f_{cu28}$$

BS8110, $E_{c28} = 5.5f_{cu28} / \mu$ and $E_t / E_{c28} = 0.4 + 0.6t / f_{28}$ where,

E_{c28} = concrete elastic modulus at 28 days.

f_{cu28} = characteristic concrete strength at 28 days.

K_o = stiffness factor of aggregates (usually taken as

20Gpa, and 0.2 is a coefficient) by Teychenne

but Code varying from 14 to 26Gpa.

t = required age in days.

And these expressions have functional relationship which the elastic modulus yields to at all points in time for consistency of analysis of the properties of materials. Hence, this project is only pivoted on the overall ideas and assumptions of the BS8110 to investigation the effects of four aggregate types (Granite, Gravel, Grey Limestone and White Polar Chippings) of the same size of 10mm, on compressive strength at 28 days.

OBJECTIVES:

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To have a thorough justification by testing the effects of these four aggregates on the Elastic modulus of concrete to conform to the generalized approach of the BS8110 expressions.

To critically compare and contrast the similarities or uniqueness between the experimental values of compressive strength targeted at 40-50N/mm² of high strength concrete.

To generally examine the aggregates stiffness in relation to Elastic modulus.

Comparing compressive strengths of concrete in different proportion by volume of fine – coarse aggregates of the concrete samples (and in this case, 30: 70% and 40: 60% ratios is used) respectively.

To verify the justification that the compressive strength of a cube is feasibly higher than the compressive strength of a cylinder when tested.

CHAPTER TWO

LITERATURE REVIEW

2. 1. 0. BACKGROUND

Concrete as heterogeneous material is categorized into normal and light weight concrete based on the design performance relating the characteristic strengths and densities of materials to suit appropriate constructions. The high strength concrete is term generally used to mean concrete with a uniaxial compressive strength value greater than 41Mpa, as assumed by the ACI committee 363. This is used for the Design of columns especially of high

residential structures, Bridge of longer spans, offshore oil platforms and so on: Nilson, Darwin and Dolan (2004: 52). Higher Elastic modulus and coefficient of creep lower reduce long-term deflection in compression. The disadvantages include the reduction in ultimate strain capacity, brittleness in compression and increase the tendency of cracks to occur and not economical. The requirement is of low water-cement ratio below 0.25 according to Nilson, Darwin and Dolan (2004: 53). low strength is otherwise known as conventional concrete having the strength less than high strength concrete according to Bashir, Almusallam and Maslehuddin; In constructional and building Materials” (2003: 97-103). High strength concrete is relative to a uniaxial compressive strength that is greater than that which is derived ordinarily in a region because maximum strength of concrete that is currently being produced varies considerably from one region to the other: Bahshir, Almusallam and Maslehuddin (2003: 2). Hence, the using of high strength brings about the reduction of cross sectional area and dead loads in a structure.

The functional mechanism of concrete depends on the overall constituent materials which are basically cement, water, fine and coarse aggregates in defined proportions with different properties resulting to characteristic strengths. The efficacy of a characteristic strength is attained only when the materials are properly selected, manufactured and designed, and the properties well defined and handled to yield desired result.

Several investigators and researchers have revealed through their experimental works the influence of materials composite on the Elastic

modulus and Compressive strength. Specifically, the Construction and <https://assignbuster.com/concrete-elastic-modulus-for-various-aggregate-types-construction-essay/>

Building Materials research (2002) and (2003). These respective Materials recognized that concrete should be properly examined as a three phase constituent materials of aggregates, cement and a transition between them. Also, that the transition zone is ranged 10-50 thick and generally seen as being the weakest component of concrete resulting to influence on the mechanical behaviour of concrete as could be compared to volumetric importance according to the Construction and Building Materials (2010: 505-512).

2. 2. 0. THE DEFECTIVES OF HIGH STRENGTH CONCRETE (HSC).

The problem of the High Strength Concrete as justified by the Construction and Building Materials (2003: 3) is that cracking is more generalize and tends to homogeneous material characteristic as compared to the normal concrete: Bashir, Almusallam, Maslehuddin (2003: 97-103). Also, High strength Concrete behaves as a linear elastic property and being subjected to brittleness than Normal concrete strength hence, cumulated that it is paramount to propound data on the mechanical properties of hardened concrete particularly, its strength in relation to the ideas of Bashir, Almusallam, Maslehuddin (2003: 97-103); further argued that there is a good correlation between the Engineering properties of concrete such as stiffness factor.

Generally, it is understood that besides the constituent materials, Mix design and Stiffness also play importance roles to enhance strength accumulation in concrete design. And the below flow chart may be used simply to illustrate

how concrete is form from various materials including design mix to achieve desired strength and durability.

DESIGN CONCRETE

MATERIALS

CEMENT, WATER, FINE AND COARSE AGGREGATES

MIX-DESIGN

PROPERTIES (Strength, Workability and Durability)

Others

Creep and Shrinkage

Elastic modulus

Fire resistance

Resistance to abrasion

Thermal conductivity

Figure 1: Concrete Flow Chart

2. 3. 0. DESIGN MATERIALS

There are basically three constituent materials of concrete for design purpose namely:

Cement.

Fine and Coarse Aggregate.

Water.

2. 3. 1. CEMENT

Cement as a design material is of various types but more importantly restricted to the Ordinary Portland type for the purpose of this investigation. It constitutes principally of chemical compound such as Dicalcium and Tricalcium Silicates in different proportions by percentage. Cement fineness and soundness are the most properties of interest to be examined to achieve desired concrete strength according to the British Standard Institution (1991: 20). It is believed that High Strength Concrete is resulting from high performance Ordinary Portland cement well ground in good proportion.

The Cement paste helps to harden concrete to gain strength through a chemical reaction known as hydration property due to curing at 28 days age. It also mixes with water to fill the void of aggregates which enables the concrete to be easily placed and flows to avoid shrinkage. An Ordinary Portland Cement is one which all the particles will pass a No. 100 sieve and over 95% will pass a No. 200 sieve in British Standard (1991) and, must have minimum strength of (compressive strength) for 3-day mortar cubes of less than 15N/mm², 7-day 23N/mm² and 3-day concrete 8N/mm² while, 7-day 14N/mm², Kong and Evans (1996: 20). Its weight is a function of the degree of compaction which is roughly taken as 1450kg/m³: Kong and Evans (1996).

2. 3. 2. AGGREGATES

Aggregates are the most important constituent materials of concrete. These materials constitute about 65-75% by volume of hardened mass occupied in concrete mix thereby, constituting the highest quota of concrete strength. The High performance strength of concrete is due to the type of aggregates to be used in design. There are two main types known as fine and coarse aggregates.

2. 3. 2. 1. Fine Aggregate

This is natural sand from a good source free of impurities and contaminations that is capable of achieving the cohesiveness of the mix and desired strength: Kong and Evans (1996). Fine Aggregate is derived from natural sand or crushed stone sand or crushed gravel with particle capable of passing a 5mm sieve by Kong and Evans.

A technically satisfied fine aggregate is one which has the capability of producing satisfactory concrete: Day (1999). It is said by Day to be standard and substandard if having the effect of retarding set, increased bleeding, excessive air entrainment, poor workability and increased water requirement, resulting in increase in shrinkage and extra cost.

Most importantly, the features of a fine aggregate that affect the functionality of a design concrete has been identified by Day (1999):

(i). Grading.

(ii). Particle shape and surface texture.

(iii). Clay.

(iv). Chemical catalysts (salt and alkaline).

(v). presence of mechanical weak particle.

(vi). Water absorption level.

(vi). source.

However, this investigation only discuss on the effect of Grading, Particle shape and texture, and more importantly source of the aggregates.

2. 3. 2. 2. Coarse Aggregates .

The properties of a coarse aggregate rely on solely the source of basic rock, the crushing process and its treatment in terms of separation into fractions, segregation and contamination as proposed by Day (1999). It is also noted that a coarse aggregate is one which is derived crushed stone, crushed gravel that can retain on a 5mm sieve according to Kong and Evans (1996). One important feature of a coarse aggregate is the bond characteristic usually associated high strength concrete which flexural and tensile strength are of special consideration, and it is a composite nature of chemical effects of surface roughness, particle shapes, water absorption and cleanliness by Day (19990).

Again, Kong and Evans (1996); propounded that the durability and chemical inert under expose condition is the most requirement of a coarse aggregate, and the size, shape and surface texture and grading are said to be physical requirements must be examined because these are characteristics which enhance the strength or weakness of concrete.

2. 4. 0. GRADING

A durable concrete must be dense, and when fresh, good enough for compaction: Kong and Evans (1996). There are voids comprise of mixture of cement, water and fine aggregate in mortar and that which is slightly more than sufficient is recommended to fill the voids of coarse and, cement paste slightly more than sufficient also to fill the voids of fine aggregate: Kong and Evans (1996). The voids are seen as functions of grading and particle size distribution by Kong and Evans.

Generally, grading is the total way of accessing or categorizing the fineness and grade to which workability of concrete can be achieved considerably at a good flow. This is carried out through a comparative idea of sieve analysis as well as particle size distribution based on the recommendation by British Standards or ASTM of sieve sizes. These sieve sizes are used to estimate the cumulative percentage of finer of the weight retained particles on each sieve. And to comply with the BS 882, the percentages for the coarse aggregate and fine aggregate should fall within the limit the below tables: Kong and Evans (1996).

Table2. 10 Grading Limits for Coarse Aggregates

Percentage by weight passing the standard sieves

Nominal size of Aggregates

Standards

sieve (mm) 40mm to 5mm 20mm to 5mm 14mm to 5mm

50. 0 100 -

37. 90-100 100

20. 0 35-70 90-100 100

14. 0 - - 90-100

10. 0 10-40 30-60 50-85

5. 0 0-5 0-10 0-10

Kong and Evans (1996: 36)

Table 2. 20 Grading Limits for Fine Aggregates

Percentage by weight passing the standard sieves

Additional Limits for Grading

Sieve Overall

Limits C M F

10. 0mm 100

5. 0mm 89-100

2. 36mm 60-100 60-100 65-100 80-100

1. 18mm 30-100 30-90 45-100 70-100

600mm 15-100 15-54 25-80 55-100

300 5-70 5-40 5-48 5-70

150mm 0-15 0-15

Kong and Evans (1996: 36).

The above tables show that especially, the fine aggregate has zone division from coarse, medium and finer. The divisions are larger based on percentage passing the 600mm meaning in a fresh concrete mix, the content of the fine aggregate penetrating has an advantage over workability.

2. 5. 0. THE CONTENT AND PARTICLE SIZE DISTRIBUTION

In the Construction and Building Materials (2010: 505-512); Meddah, Zitouni and Belaabes used the effect of content and particle size distribution of coarse aggregate on the compressive strength as a base for argument of concrete strength. This revealed that several properties of aggregate such as degree of weathering, specific gravity, hardness, chemical, and mineral composition, shape, roughness, physical and chemical stability and pore structure are connected to the parent rock.

Also, that adequate proportion of granular fractions depend on the type of concrete targeted and thereby, used similar aggregates such as Limestone, Basalt, Diabase, Granite and Quartz of the sizes of 15mm and 25mm for comparison; and ascertained after experimentation that the great effect on the usefulness of aggregates is largely depends on the particle size distribution. Meddah, Zitouni and Belaabes (2010) came to conclusion that;

The value of compressive strength of normal concrete increases with the maximum size of coarse aggregates.

The content of the coarse aggregates has a great influence on the compressive strength of both normal and high strength concrete, and increase in compressive strength is succeeded.

The advantage of the coarse aggregate grains distribution on compressive strength of High Strength concrete is significant as compared to the Normal concrete.

The compressive strength is strongly connected to the coarse aggregates parameters such as content proportion of fine to coarse aggregate and grain distribution of concrete mixture.

Furthermore, Kong and Evans (1996) also supports these arguments but emphasize that higher coarse aggregate sizes results to lower water/cement ratio to achieve reasonable workability and higher strength of concrete. The reduced water/cement ratio is been offset by the strong effect of the lower bond area at the interface of the cement paste and the aggregate and of the discontinuities caused by the large particles.

2. 6. 0. EFFECT OF AGGREGATE SOURCE

Relative to the action of various aggregate types on concrete properties called Elastic Modulus and compressive strength, several researches have been carried out by different people to justify the boredom to study how the negative impacts are reduced considerably on concrete strength collective sources of aggregates.

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In the Magazine of Concrete Research of (1999: 291-304); this work reported the applicability of the BS approach to a range of 13 different aggregate types from a source in South Africa that the strength of concrete depends not only on stiffness, particle sizes, shape and texture, mix design but on selected sources of the aggregates. The source of controls the physical properties such as Relative Density RD, Loose Bulk Density LBD, and Consolidated Bulk Density CBD, water absorption and Coefficient of thermal expansion should be examined in addition. Thus, Alexander (1991: 291-304) concluded the results of his experimentation after thorough comparison to others that different aggregates produce different compressive and Elastic Modulus depending on their sources of selection which should be free from contaminations such as sodium chloride or alkaline and, was strongly supported by Day (1999); that chloride content of aggregates collected from beach sand is contaminated than dredge sand from sea. This contamination cause efflorescence and higher shrinkage and utter the setting and handing rates of concrete.

2. 7. 0. WATER

Water is necessary for the design of concrete since it enables the concrete to be properly mix the constituent materials together for compatibility. This design water should be free of contamination of sodium chloride, oils, alkalis and sugar which are catalysts to reduce the effect or workability of the constituent materials of concrete. The requirement for water testing has been provided by the BS3148 for concrete suitability. Suitable water of concrete is otherwise known as design water when the measured volume is enabled to be predicted by the idea of mix design. It is also known as <https://assignbuster.com/concrete-elastic-modulus-for-various-aggregate-types-construction-essay/>

consumable water or hygienic water is necessary in concrete cast to have the desired strength and, if water is suspected to be contaminated, it is advisable by the BS3148 to run or cast a series of test sample made of contaminated and hygienic water to enable the designer to predict its effect on concrete and made decision on the selection of minimum quantity or volume of water is required for optimum strength of concrete whereas, large volume of water gives low strength of concrete. Excess volume of water leads to loss of slump. Workability of concrete depends on the water content used for design when considering the water/cement ratio criterion of mix design.

2. 80. PRACTICAL MIX-DESIGN

The term Mix-Design is the ability or a medium of selecting good components of concrete known as binders that are normally accessed on batching by weight or volume. The major aim of mix design is to select the optimum ratio of cement, water and aggregates to achieve a concrete with desired strength, workability, durability and economy: Kong and Evans (1996: 50). It is strongly emphasize by Kong and Evans that practical mix design are based on the free water/cement ratio as the most important factor and the water content to determine or influence the strength of concrete. The batching relative to weight is preferably important in design of concrete for desired strength, and the idea or process revolves round water/cement proportion for batching weight of concrete for conventional aggregates especially with a constant density in question.

2. 8. 1. Water- Cement Ratio In general practice of concrete technology, water/cement ratio is perhaps the most important emphasized parameter to be examined in design. The base point of a typical mix design is the proper placed value of the water/cement ratio. It is simply the ratio of water to cement in terms of weight: Kong and Evans (1996). Practical mix design methods engaged the free water/cement and water content which are the two required factors that influence the strength, durability and workability of concrete. In the calculation of the water/cement ratio only the weight of the free water is used amongst the overall water absorbed by the aggregates and, it is the total water less the absorbed water while, the water content is the weight of the free water per unit volume of concrete: Kong and Evans (1996: 50). Kong and Evans emphasized that the establishment by an initial mixes otherwise known as trails batch or adjustments on site: supported by Day (1999). Both researchers recognised that there are two basically main methods of mix design captured from the works of Road Research Laboratory, the American Concrete Institute and Department of the Environment DoE known as the Traditional and DoE mixes. The water/cement ratio is chosen for strength and workability at average of 28 days called the mean target strength relative to characteristic strength: value that exceeds by a suitable margin known as current margin.

2. 90. DURABILITY/ PEAMEABILITY OF CONCRETE

2. 9. 1. Durability

The ability of a concrete to achieve its purpose of design in service is very important in design. The parameters that influence the potential integrity of

concrete is over estimated in terms of durability of concrete. The provision of appropriate workability, suitable cement, aggregates and water as major ingredients of concrete in accordance with given standard and codes of practice are the base line. The tendency of concrete to exhibit a free corrosive nature and, a maximum protection against external forms of attack is impinge upon the correct choice of materials and adequate proportions: Lydon (1983). Durable design concrete is stable and capable of withstanding all the environmental conditions to which it is exposed: Kong and Evans (1996: 38).

2. 9. 2 Permeability

Permeability of concrete is related to durability and it is the crawl at which water can pass through the concrete: Kong and Evans (1996: 39). Low permeable enables the concrete to withstand the effects of weathering, rain and action of freezing and thawing exposed conditions. The permeability of concrete increase rapidly with amount of voids and water/cement ratio and, when the amount over influxes the strength of concrete reduces. It is advisable that permeability should not exceed 7% else, bound to be corrosion in case of reinforcement: Kong and Evans (1996).

2. 10. CREEP PROPERTY OF CONCRETE.

Creep is a property of concrete that depends on loading duration. When there is an increase in strength in concrete with age, it is said to be under creeping condition. Creep is not actually proportional to strength but inversely related and can be estimated provided the strength-age could be determined. This is generally relative to the creep values of specimen <https://assignbuster.com/concrete-elastic-modulus-for-various-aggregate-types-construction-essay/>

concrete mixes which is derived from loading to one-third of the cube strength at 28 days curing age: Kong and Evans (1996: 30). The concrete is unlikely to be stressed beyond one-half of the cube strength and, the creep of concrete at specified period of loading is roughly estimated to be proportional to the stress by Kong and Evans. Different concrete of the same cement paste content would produce creep that is approximately proportional to the stress/ strength ratio. Desired strength unaffected by creep is determined with respect to the avoidance of long term loading duration of concrete. The rate at which creep increases depends on the increase in temperature as a linear function and, at a value of 1% of the 15 oC creep for each degree Celsius: Kong and Evans (1996: 31). Generally, aggregate-cement ratio, aggregate content, cement content and water content do not have any significant effect on creep but water-cement ratio and cement type influence the level of creep in concrete design.

2. 11. SHRINKAGE PROPERTY OF CONCRETE

The shortening in length or contraction of concrete as a result of absorption of water in the gel is related to dry shrinkage: Kong and Evans (1996: 33). It is a physical property of concrete unlike creep of chemical influence.

Aggregate content, fineness of cement, and temperature influence the level of shrinkage of concrete. Low shrinkage concrete contains non-shrinking aggregates like limestone Quartzite gravel, mountain limestone, blast furnace slag, dolomite, granite and so on: Kong and Evans (1996: 35). While, high shrinkage is as a result of aggregates volume change on wetting and drying such as slate, sandstone, basalt so on. Both coarse and fine

aggregates influence the level of concrete shrinkage more importantly and, <https://assignbuster.com/concrete-elastic-modulus-for-various-aggregate-types-construction-essay/>

shrinkage is been reduced by using various aggregates of high Moduli of Elasticity that are dense and hard.

2. 11. 1. Aggregates Shrinkage Mechanism In Concrete

Aggregates do undergo change in volume because they contain some minerals in form of clay which swell up when absorbing water or dry out and shrink. During setting of concrete, the cement paste volume changes. Forces are exerted during setting on aggregates resulting in moisture content affecting the overall size of the aggregate. The total weight of aggregates is that which is related to Elastic modulus and the volume ratio of the cement paste. It is reasonable to say that all aggregates suppose to be shrinkable to a greater or less extent as well as change in volume for proper classifications and selections for high or low shrinkage types: Pike (1990). The effect of high shrinkage causes unwanted movement or cracks and reduction in durability of concrete thereby leads to corrosion of the reinforcement members.

2. 12. CONCRETE STRENGTH

The design strength is associated with Compressive strength of concrete which is the common measure for judging a standard durable concrete at 28 days curing age. Buildings and other Engineering structures are purely designed with the most performance estimate of the compressive strength for stability, workability and durability of concrete. In the National Ready Mix Concrete association (NRMCA: 2003); compressive strength is generally regarded as a measure by breaking Cylindrical Concrete Specimens in a Compressive Testing Machine basically, based on the precepts of the BS8110 and ASTM. The estimation of compressive strength is derived from the failure <https://assignbuster.com/concrete-elastic-modulus-for-various-aggregate-types-construction-essay/>

load over the cross-sectional area that is resisting the load of unit of mega Pasca (Mpa); an International standard Unit of measurement: BS8110 (1985) and NRMCA (2003). Compressive Strength of concrete varies from 17-28Mpa. The compressive needs to be determined from a concrete mixture to attain the desired or required strength for specified for a job. The strength tested results from cast concrete cylinder is used for quality control, estimation of strength or acceptance of concrete in