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A REVIEW PAPER ON CONCRETE MIX DESIGN OF M20 CONCRETE

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ABSTRACT

The concrete is the most commonconstruction material. Generally, it produced by using cement, sand, aggregate and water it's act as binding material in the whole construction world. The ingredients are used as per designedproportion, termed as nominal mix or design mix concrete. In the nominal mix concrete, the properties ofingredients are not considered and same is limited uptoM20 grade only. For the present work, 53 gradeordinary Portland cement (OPC) was used in nominalmixed and design mixed M20 grade concrete and requiredcement content is compared.By using 20 mm size the graded angular aggregate and the river sand, the nominal mix concrete (1.0 : 1.5 : 3.0) is prepared. The density and cement content of fresh concrete were 24.46 KN/m3 and 395.83 kg/m3 respectively. By using the same ingredients, the nominal mix concrete is prepared using the ratio given in IS 456: 2000 table – 9 and the cement content is found 366.30 kg/m3. Nominal mix M20 grade fresh concrete was again prepared by using 20 mm size angular coarse aggregate and cement content was obtained as 366.52 kg/m3.Design mix proportions were calculated by using and 53 grade OPC with 20 mm size graded angular aggregate and river sand. The cement content is found 48.20 kg/m3 less for 53 gradeOPC and cement the saving is 4.08% over 43 grade cement and more for other grade cement.

Keywords*: aggregate, concrete, density*

I. INTRODUCTION

In concrete, the cement is most common binding material. The cement mortar acts as a suspension media for the aggregates. For the higher grade concrete, the cement content is increases and maximum use of OPC is limited to 455 kg/m3 of concrete as per (IS 456: 2000, 8.2.4.2). For a particular grade of concrete, cement content varies with respect to its type, w/c ratio, water content, properties of aggregates such as shape, size, grading, zoning, fineness modulus, angularity number, surface features, specific gravity etc. Nominal mix concrete is permitted for M20 and lower grade concrete and from durability aspect, use of M20 grade reinforced concrete is limited in mild exposure condition with maximum free w/c 0.55 and minimum cement content 300 kg/m3 of concrete. Maximum free w/c is affected by grade of concrete, type of coarse aggregate, workability requirement, exposure condition and use of mineral /chemical admixtures etc. For nominal mix M20 grade concrete proportion of the ingredient in field is taken as cement (1.0): FA (1.5): CA (3.0) with suitable water content to meet the workability requirement. As per Table-9, of IS 456: 2000, in nominal mix M20 grade concrete 50 kg cement and 30 litre water are to be mixed with 250 kg aggregates.The process of selecting suitable ingredients of concrete and determining their relative quantities with the objective of producing a concrete of the required strength, objective of producing a concrete of the required strength, durability, and workability as economically as possible, istermed the concrete mix design. Properties of hardened concrete depend upon properties of ingredients, their proportion, quality control, functioning machineries, skill of manpower and their involvement, effectiveness of production stages etc. These factors result uncertainty in uniformity of samples and for the same, failure of 5% samples below required strength is acceptable. On testing, a sample has different strength within acceptable range and for the same assumed or calculated standard deviation is used in calculating target strength.

Accordingly, for a given characteristics compressive strength (f_{ck}), concrete mix is designed for higher target strength (f_t) including the concept of standard deviation and percentage failure of samples. As per provisions ofIS 456: 2000 and IS 10262 : 2009[4] proportion of ingredients for design mix concrete is calculated. Proportion of trial mix-I is calculated and fresh concrete is checked for workability. On satisfying the workability requirement, it is termed as trial mix-II otherwise recalculated with suitable adjustment(s) and same is designated as trial mix-II. As the various properties of ingredients are not considered in mix design calculation, trial mix-III and trial mix-IV are calculated by keeping water content as constant and changing w/c by ± 10%. Cubes are casted from trial mixes and after 28 dayscuring, samples of all three trial mixes are tested for compressive strength. Test results satisfying

0acceptance criteria, are used for finding average strength for all three trial mixes. Graph plot between w/c and average compressive strength of trial mixes is used for calculating final w/c required for target strength. By using the same w/c, final mix proportion is calculated and designated as the design mix concrete of requisite grade.

II. MATERIALS AND METHODOLOGY

For this study, 53 grade ordinary Portland cement were used. Graded angular aggregates of nominal size 20 mm; and river sand were used. Specific gravity of CA and FA was 2.56 and 2.61 respectively. Mix proportion was calculated on saturated surface dry condition of aggregates. Workability of fresh concrete was selected as 25-50 mm slump value for normal concreting in mild exposure condition. Yield of nominal mix M20 grade concrete was determined by specific gravity method and the same was verified by density of fresh concrete. Cement content was calculated from verified yield of concrete. Based on code provisions of IS 10262 : 2009, design mix proportions for M20 grade concrete for different ingredient compositions were calculated.

III. NOMINAL MIX M20 GRADE CONCRETE

In the past the specifications for concrete prescribed the proportions of cement, fine and coarse aggregates these mixes Proportions of cement, fine and coarse aggregates. These mixes of fixed cement-aggregateratio which ensures adequate strength are termed nominal mixes. These offers implicity and under normal circumstances, have a margin of strength above that specified .however, due to the variability of mixing in gredients the nominal concrete for a given work ability varies widely in strength. In nominal mix M20 grade concrete, graded angular aggregate of nominal size 20 mm, zone II river sand, 53 grade OPC were used in conventional ratio 1.00 (cement) : 1.5 (sand) : 3.0 (CA). For required workability, w/c was maintained as 0.50. Density and cement content of the fresh concrete were found 23.46 KN/m^3 and 395 Kg/m^3 respectively. As per provisions in IS 456 : 2000 Table – 9, for nominal mix M20 grade concrete, selected proportion was 1.00 (zone II river sand) : 2.50 (40 mm graded angular aggregate) and w/c adjusted to 0.50 for required workability. For 50 cement, 255 kg aggregates and 25 litre water, yield of concrete was 136.55litre and cement content was 365 kg/m^3 of concrete. Using 20 mm graded angular aggregate in the same nominal mix concrete, cement content was found 365 kg/m^3 of concrete.

IV. STANDARD MIX M20 GRADE CONRETE

The nominal mixes of fixed cement and aggregate ratio (by volume) vary widely in strength, may result in under or over rich mixes. For that reason, the minimum compressive strength has included in many specifications. Those mixes are termed standard mixes. The IS 456-2000 has designated the concrete mixes into a number of grades as M10, M15, M20, M25, M30, M35 and M40. In this designation the letter M refers to the mix and the number to the specified 28 day cube strength, the number to the specified 28 day cube strength of mix in N/mm2. The mixes of grades M15, M20 and M25 correspond approximately to the mix proportions (1:2:4), (1:1.5:3) and (1:1:2) respectively.

V. DESIGN MIX M20 GRADE CONCRETE

It is a performance based mix where choice of ingredients and proportioning are left to the designer to be decided. The user has to specify only the requirements of concrete in fresh as well as hardened state. The requirement in fresh concrete are workability and finishing characteristics, whereas in hardened concrete these are mainly the compressive strength and durability.

For the design mix M20 grade concrete, trial mix and final mixproportions are calculated by using graded angular aggregate of nominal size 20 mm, zone II river sand and 53 grade OPC in the following steps:

Calculation of target strength (f_t) for mix proportioning

This is calculated for characteristic compressive strength at 28 days (f_{ck}) , standard deviation (s) by an expression $f_t = f_{ck} + 1.65$. From the table-1 (IS:10262:2009), value of the standard deviation are taken as 4.0 N/mm^2 and accordingly target strength is to be 26.6 N/mm^2.

Selection of free water cement ratio (w/c) and watercontent

From the table-5 of IS 456: 2000, free w/c for M20 grade concrete in mild exposure condition is selected 0.55. However from the experience and data available in laboratory w/c is reduced to 0.50. For the saturated surface dry

(SSD) aggregates, water content in concrete mix is decided. As per table-2 (IS 10262:2009) , maximum water content for 20 mm nominal maximum size aggregate with 25 to 50 mm slump was kept as 165 kg/ m^3 of a concrete.

Calculation of cement content

From the table-5 and 6 (IS 456:2000), minimum cement content required for the durability aspect for mild exposure conditions with 20 mm aggregate was 270 kg/m^3. For the water content 165 kg/m^3 and free water cement ratio 0.50, cement content is 330 kg/m^3, higher than the minimum requirements.

Proportion of volume of coarse aggregate and fine aggregate content

From the table – 3 (IS 10262:2009), volume of fineand coarse aggregates for the 20 mm size coarse aggregate, fine aggregate of zone II and water cement ratio 0.50 is 0.71 and 0.29 respectively.

Calculation of mass of CA and FA

For 1m^3 of the concrete, the volume of cement, water and all in aggregate is 0.1048 m^3, 0.165 m^3 and 0.7302 m^3 respectively. For the specific gravity of CA and FA being 2.6 and 2.65, mass of CA and FA, in 0.7302 m^3volume of total aggregate is 1348.02 kg/ m^3 and 561.19 kg/ m^3 respectively. The proportion of ingredients, water : cement : sand : coarse aggregate is 0.50 : 1.00 : 1.70 : 4.08 respectively.

Checking for workability

By using ingredients in the above proportions, fresh concrete is prepared and its slump value is found 33 mm. On satisfied workability requirement, it is designated as trail mix II and separates set of cubes were casted using 53 grade OPC for testing after 28 days curing.

Trial Mix-III & IV and final mix

By using the same ingredients, trial mix-III is calculated by maintaining water content as constant and use w/c as 0.55. For 1m^3 of the concrete, mass of water, cement, FA and CA is 165 kg, 300.00 kg, 588.11 kg, 1346.37respectively. The mass of ingredients for trial mix-IV is also calculated by using w/c 0.45. The cubes were casted for trail mix-III and trial mix IV for both grades of cement. After 28 days curing, samples of three trial mixes with 53 grade OPC were tested. By using average of acceptable four test results of all three trial mixes, the graph is plotted (IS 10262:2009) and from the same graph w/c for target strength (f_t) was calculated as 0.49. By using the same w/c ratio, the final mix proportion is calculates and mass of cement, sand and coarse aggregate for 1m^3 of concrete is 336.73 kg, 555.69 kg and 1347.86 kg respectively. Similarly the proportion of final mix is calculated by using 53 grade OPC with the same ingredients and cement content is 323.53 kg/m^3 concrete.

VI. CONCLUSION

Density of the normal concrete is in the order of 2000 to 2500 kg/m3.This heavy self weight will make it to some extent an uneconomical structural material. Attempts have been made in the past to reduce the self weight of concrete to increase the efficiency of concrete as a structural material. The light-weight concrete which is used for construction the density should varies from 300 to 1850 kg/m3. The workability of the all concretes are very good than normal concrete. To get uniform mixing of concrete for construction it must be mix 5minutes minimum. The aggregates are added in insulating concrete at the end of mixing to minimize degradation of concrete. Structural light-weight aggregate concrete is a concrete having 28 days compressive strength more than 17 Mpa and 28 day air dried unit weight not exceeding 1850 kg/m3 . Finally the density of the concrete is nearly half of less than conventional concrete. The strength is nearly equals to the conventional concrete. The economy is good than conventional concrete. Design mix concrete with 20 mmCA, zone III sand and 53 grade OPC resulted 5.79% higher cement content over nominal mix concrete as per codal provisions. Cement content in nominal mix concrete with conventional ratio was 7.32 kg/m^3 and3.33 kg/m^3 higher than the same for design mix concrete with 20 mm CA, 43 grade OPC and; zone II and zone III sand respectively. As the cement content in nominal mix concrete with codal provisions was less than the design mix M20 concrete, use of design mix M20 grade concrete was found more appropriate for lower size aggregates.

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