MODULE-3

MIX DESIGN - Factors affecting mix design, design of concrete mix by BIS method using IS10262 and current American (ACI)/ British (BS) methods. Provisions in revised IS10262-2004.

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible, is termed the concrete mix design. The proportioning of ingredient of concrete is governed by the required performance of concrete in 2 states, namely the plastic and the hardened states. If the plastic concrete is not workable, it cannot be properly placed and compacted. The property of workability, therefore, becomes of vital importance. The compressive strength of hardened concrete which is generally considered to be an index of its other properties, depends upon many factors, e.g. quality and quantity of cement, water and aggregates; batching and mixing; placing, compaction and curing. The cost of concrete is made up of the cost of materials, plant and labour. The variations in the cost of materials arise from the fact that the cement is several times costly than the aggregate, thus the aim is to produce as lean a mix as possible. From technical point of view the rich mixes may lead to high shrinkage and cracking in the structural concrete, and to evolution of high heat of hydration in mass concrete which may cause cracking. The actual cost of concrete is related to the cost of materials required for producing a minimum mean strength called characteristic strength that is specified by the designer of the structure. This depends on the quality control measures, but there is no doubt that the quality control adds to the cost of concrete. The extent of quality control is often an economic compromise, and depends on the size and type of job. The cost of labour depends on the workability of mix, e.g., a concrete mix of inadequate workability may result in a high cost of labour to obtain a degree of compaction with available equipment.

2. Requirements of concrete mix design

The requirements which form the basis of selection and proportioning of mix

ingredients are :

a) The minimum compressive strength required from structural consideration

b) The adequate workability necessary for full compaction with the compacting equipment available.

c) Maximum water-cement ratio and/or maximum cement content to give adequate durability for the particular site conditions

d) Maximum cement content to avoid shrinkage cracking due to temperature cycle in mass concrete.

2.1 Types of Mixes

i. Nominal Mixes

In the past the specifications for concrete prescribed the proportions of cement, fine and coarse aggregates. These mixes of fixed cement-aggregate ratio which ensures adequate strength are termed nominal mixes. These offer simplicity and under normal circumstances, have a margin of strength above that specified. However, due to the variability of mix ingredients the nominal concrete for a given workability varies widely in strength.

ii. Standard mixes

The nominal mixes of fixed cement-aggregate ratio (by volume) vary widely in strength and may result in under- or over-rich mixes. For this reason, the minimum compressive strength has been included in many specifications. These mixes are termed standard mixes. 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 of mix in N/mm2. The mixes of grades M10, M15, M20 and M25 correspond approximately to the mix proportions (1:3:6), (1:2:4), (1:1.5:3) and (1:1:2) respectively.

iii. Designed Mixes

In these mixes the performance of the concrete is specified by the designer but the mix proportions are determined by the producer of concrete, except that the minimum cement content can be laid down. This is most rational approach to the selection of mix proportions with specific materials in mind possessing more or less unique characteristics. The approach results in the production of concrete with the appropriate properties most economically. However, the designed mix does not serve as a guide since this does not guarantee the correct mix proportions for the prescribed performance. For the concrete with undemanding performance nominal or standard mixes (prescribed in the codes by quantities of dry ingredients per cubic meter and by slump) may be used only for very small jobs, when the 28-day strength of concrete does not exceed 30 N/mm2. No control testing is necessary reliance being placed on the masses of the ingredients.

3. Factors affecting the choice of mix proportions

The various factors affecting the mix design are:

3.1. Compressive strength

It is one of the most important properties of concrete and influences many other describable properties of the hardened concrete. The mean compressive strength required at a specific age, usually 28 days, determines the nominal water-cement ratio of the mix. The other factor affecting the strength of concrete at a given age and cured at a prescribed temperature is the degree of compaction. According to

Abraham‟s law the strength of fully compacted concrete is inversely proportional to the water-cement ratio.

3.2. Workability

The degree of workability required depends on three factors. These are the size of the section to be concreted, the amount of reinforcement, and the method of compaction to be used. For the narrow and complicated section with numerous corners or inaccessible parts, the concrete must have a high workability so that full compaction can be achieved with a reasonable amount of effort. This also applies to the embedded steel sections. The desired workability depends on the compacting equipment available at the site.

3.3. Durability

The durability of concrete is its resistance to the aggressive environmental conditions. High strength concrete is generally more durable than low strength concrete. In the situations when the high strength is not necessary but the conditions of exposure are such that high durability is vital, the durability requirement will determine the water-cement ratio to be used.

3.4. Maximum nominal size of aggregate

In general, larger the maximum size of aggregate, smaller is the cement requirement for a particular water-cement ratio, because the workability of concrete increases with increase in maximum size of the aggregate. However, the compressive strength tends to increase with the decrease in size of aggregate.

IS 456:2000 and IS 1343:1980 recommend that the nominal size of the aggregate should be as large as possible.

3.5. Grading and type of aggregate

The grading of aggregate influences the mix proportions for a specified workability and watercement ratio. Coarser the grading leaner will be mix which can be used. Very lean mix is not desirable since it does not contain enough finer material to make the concrete cohesive. The type of aggregate influences strongly the aggregate-cement ratio for the desired workability and stipulated water cement ratio. An important feature of a satisfactory aggregate is the uniformity of the grading which can be achieved by mixing different size fractions.

3.6. Quality Control

The degree of control can be estimated statistically by the variations in test results. The variation in strength results from the variations in the properties of the mix ingredients and lack of control of accuracy in batching, mixing, placing, curing and testing. The lower the difference between the mean and minimum strengths of the mix lower will be the cement-content required. The factor controlling this difference is termed as quality control.

4 Mix Proportion designations

The common method of expressing the proportions of ingredients of a concrete mix is in the terms of parts or ratios of cement, fine and coarse aggregates. For e.g., a concrete mix of proportions 1:2:4 means that cement, fine and coarse aggregate are in the ratio 1:2:4 or the mix contains one part of cement, two parts of fine aggregate and four parts of coarse aggregate. The proportions are either by volume or by mass. The water-cement ratio is usually expressed in mass.

4.1 Factors to be considered for mix design

• The grade designation giving the characteristic strength requirement of concrete.

• The type of cement influences the rate of development of compressive strength of concrete.

• Maximum nominal size of aggregates to be used in concrete may be as large as

possible within the limits prescribed by IS 456:2000.

• The cement content is to be limited from shrinkage, cracking and creep.

• The workability of concrete for satisfactory placing and compaction is related to

the size and shape of section, quantity and spacing of reinforcement and technique used for transportation, placing and compaction.

5. Examples of concrete mix proportioning

1 Problems

1 - M40 pumpable concrete

A-1 Design stipulations for proportioning

a) Grade designation : M40

b) Type of cement : OPC 43 grade confirming to IS 8112

c) Maximum nominal size of aggregates : 20 mm

d) Minimum cement content : 320 kg/m3

e) Maximum water cement ratio : 0.45

f) Workability : 100 mm (slump)

g) Exposure condition : Severe (for reinforced concrete)

h) Method of concrete placing : Pumping

i) Degree of supervision : Good

j) Type of aggregate : Crushed angular aggregate

k) Maximum cement content : 450 kg/m3

l) Chemical admixture type : Superplsticiser

A-2 TEST DATA FOR MATERIALS

a) Cement used : OPC 43 grade confirming to IS 8112

b) Specific gravity of cement : 3.15

c) Chemical admixture : Superplasticiser conforming to IS 9103

d) Specific gravity of

Coarse aggregate :
2.74 Fine aggregate :
2.74 e) Water
absorption

Coarse aggregate : 0.5 percent

Fine aggregate : 1.0 percent f)

Free (surface) moisture

Coarse aggregate : Nil (absorbed moisture also nil)

Fine aggregate : Nil

g) Sieve analysis

Coarse aggregate : Conforming to Table 2 of IS: 383

Fine aggregate : Conforming to Zone I of IS: 383

A-3 TARGET STRENGTH FOR MIX PROPORTIONING

f‘ck = fck + 1.65 s

Where

f‘ck = Target average compressive strength at 28 days,

fck = Characteristic compressive strength at 28 days, s=

Standard deviation

From Table 1 standard deviation, s = 5 N/mm2

Therefore target strength = 40 + 1.65 x 5 = 48.25 N/mm2

A-4 SELECTION OF WATER CEMENT RATIO

From Table 5 of IS:456-2000, maximum water cement ratio = 0.45
Based on experience adopt water cement ratio as 0.40

0.4 < 0.45, hence ok

A-5 SELECTION OF WATER CONTENT

From Table-2, maximum water content = 186 liters (for 25mm – 50mm slump range and for 20 mm aggregates)

Estimated water content for 100 mm slump = 186 + 6/100 x186 = 197 liters

As superplsticiser is used, the water content can be reduced up to 20 percent and above Based on trials with SP water content reduction of 29 percent has been achieved.

Hence the water content arrived = 19 x 0.71 =140 liters

A-6 CALCULATION OF CEMENT CONTENT

Water cement ratio = 0.40

Cement content = 140/0.40 = 350 kg/m3

From Table 5 of IS: 456, minimum cement content for severe exposure condition = 320 kg/m3

350 kg/m3 > 320 kg/m3, hence OK

A-7 PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE

AGGREGATE CONTENT

From Table 3, volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone I) for water-cement ratio of 0.50 =0.60

In the present case w/c= 0.40. The volume of coarse aggregate is required to be increased to decrease the fine aggregate content. As w/c ratio is lower by 0.10, increase the coarse aggregate volume by 0.02 (at the rate of -/+ 0.01 for every +/-0.05 change in water cement ratio). Therefore corrected volume of coarse aggregate for w/c of 0.40 =0.62

Note: In case the coarse aggregate is not angular, then also the volume of CA may be required to be increased suitably based on experience.

For pumpable concrete these values should be reduced by 10 percent
Therefore volume of coarse aggregate = 0.62 x 0.9 = 0.56

Volume of fine aggregate content = 1- 0.56 = 0.44

A-8 MIX CALCULATIONS

The mix calculations per unit volume of concrete shall be as follows

a) Volume of concrete = 1 m3

b) Volume of cement = = [350/3.15] x [1/1000] = 0.111 m3

c) Volume of water = [140/1] x [1/1000] = 0.140 m3

d) Volume of chemical admixture = [7/1.145] x [1/1000] = 0.006 m3
(SP 2%by mass of cement)

e) Volume of all in aggregates (e) =a – (b + c + d)

= 1 – (0.111 + 0.140 + 0.006) = 0.743 m3

f) Volume of coarse aggregates = e x Volume of CA x specific gravity of CA = 0.743 x 0.56 x 2.74 x 1000 = 11140 kg

g) Volume of fine aggregates = e x Volume of FA x specific gravity of FA = 0.743 x 0.44 x 2.74 x 1000 = 896 kg

A-9 MIX PROPORTIONS FOR TRIAL NUMBER 1

Cement = 350 kg/m3 Water = 140 kg/m3

Fine aggregate = 896 kg/m3
Coarse aggregates = 1140 kg/m3
Chemical admixture = 7 kg/m3
Water cement ratio = 0.40

Aggregates are assumed to be in SSD. Otherwise corrections are to be applied while calculating the water content. Necessary corrections are also required to be made in mass of aggregates.

A-10 The slump shall be measured and the water content and dosages ofadmixture shall be adjusted for achieving the required slump based on trials, if required. The mix proportions shall be reworked for the actual water content and checked for durability requirements.

A-11 Two more trials having variation of ± 10 percent of water cement ratio in

A-10 shall be carried out keeping water content constant, and a graph betweenthree water cement ratios and their corresponding strengths shall be plotted to work out the mix proportions for the given target strength for field trials. However, durability requirements shall be met.

Problem 2

Illustrative examples on concrete mix proportioning [M40 pumpable concrete with fly ash]

A-1 Design stipulations for proportioning

m) Grade designation : M40

n) Type of cement : OPC 43 grade confirming to IS 8112

o) Type of mineral admixture : Fly ash confirming to IS 3812 (Part-1)

p) Maximum nominal size of aggregates : 20 mm

q) Minimum cement content : 320 kg/m3

r) Maximum water cement ratio : 0.45

s) Workability : 100 mm (slump)

t) Exposure condition : Severe (for reinforced concrete)

u) Method of concrete placing : Pumping

v) Degree of supervision : Good

w) Type of aggregate : Crushed angular aggregate

x) Maximum cement content : 450 kg/m3

y) Chemical admixture type : Superplsticiser

A-2 TEST DATA FOR MATERIALS

h) Cement used : OPC 43 grade confirming to IS 8112

i) Specific gravity of cement : 3.15

z) Fly ash used : Fly ash confirming to IS 3812 (Part-1)

j) Specific gravity of fly ash : 2.2

k) Chemical admixture : Superplasticiser conforming to IS 9103

l) Specific gravity of

Coarse aggregate :2.74

Fine aggregate : 2.74

m) Water absorption

Coarse aggregate : 0.5 percent

Fine aggregate : 1.0 percent n)

Free (surface) moisture

Coarse aggregate : Nil (absorbed moisture also nil)

Fine aggregate : Nil

o) Sieve analysis

Coarse aggregate : Conforming to Table 2 of IS: 383

Fine aggregate : Conforming to Zone I of IS: 383

A-3 TARGET STRENGTH FOR MIX PROPORTIONING

f‟ ck = fck + 1.65 s

Where

f‟ ck = Target average compressive strength at 28 days,

fck = Characteristic compressive strength at 28 days, s=

Standard deviation

From Table 1 standard deviation, s = 5 N/mm2

Therefore target strength = 40 + 1.65 x 5 = 48.25 N/mm2

A-4 SELECTION OF WATER CEMENT RATIO

From Table 5 of IS:456-2000, maximum water cement ratio = 0.45

Based on experience adopt water cement ratio as 0.40

0.4 < 0.45, hence ok

A-5 SELECTION OF WATER CONTENT

From Table-2, maximum water content = 186 liters (for 25mm – 50mm slump range and for 20 mm aggregates) Estimated water content for 100 mm slump = 186 + 6/100 x186 = 197 liters As superplsticiser is used, the water content can be reduced up to 20 percent and above Based on trials with SP water content reduction of 29 percent has been achieved. Hence the water content arrived = 19 x 0.71 =140 liters

A-6 CALCULATION OF CEMENT CONTENT

Water cement ratio = 0.40

Cement content = 140/0.40 = 350 kg/m3

From Table 5 of IS: 456, minimum cement content for severe exposure condition = 320 kg/m3

350 kg/m3 > 320 kg/m3, hence OK

For proportioning fly ash concrete, the suggested steps are; Decide the percentage of fly ash to be used based on [project requirement and quality of Materials In certain situations increase in cementitious material content may be warranted. The decision on increase in cementitious material content and its percentage may be based on experience and trial. The example is with increase of 10% of cementitious material content.

Cementitious material content 1.1 x 350 = 385 kg/m3

Water content = 140 kg/m3

Water cement ratio = 140/385 = 0.364 _0.40

Let us use fly as at 30 percent of cementitious material content in addition to cement Fly ash = 385 x 0.3 = 115 kg/m3

Cement =385-115=270 kg/m3

(Saving of cement compared to previous design = 350-279 = 80 kg/m3 and fly ash utilization = 115 kg/m3)

From Table 3, volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone I) for water-cement ratio of 0.50 =0.60 In the present case w/c= 0.40. The volume of coarse aggregate is required to be increased to decrease the fine aggregate content. As w/c ratio is lower by 0.10, increase the coarse aggregate volume by 0.02 (at the rate of -/+ 0.01 for every +/- 0.05 change in water cement ratio). Therefore, corrected volume of coarse aggregate for w/c of 0.40 =0.62.

Note: In case the coarse aggregate is not angular, then also the volume of CA may be required to be increased suitably based on experience For pumpable concretethese values should be reduced by 10 percent.

Therefore volume of coarse aggregate = 0.62 x 0.9 = 0.56

Volume of fine aggregate content = 1- 0.56 = 0.44

A-8 MIX CALCULATIONS

The mix calculations per unit volume of concrete shall be as follows

h) Volume of concrete = 1 m3

i) Volume of cement =

= [270/3.15] x [1/1000] = 0.086 m3

j) Volume of fly ash = [115/2.2] x [1/1000] = 0.052 m3

k) Volume of water = [140/1] x [1/1000] = 0.140 m3

l) Volume of chemical admixture = [7.7/1.145] x [1/1000] = 0.007 m3

(SP 2%by mass of cementitious material)

m) Volume of all in aggregates (e) =a – (b + c + d)

= 1 – (0.086 + 0.052 + 0.140 + 0.007) = 0.715 m3

n) Volume of coarse aggregates = e x Volume of CA x specific gravity of CA

= 0.715 x 0.56 x 2.74 x 1000 = 1097 kg

o) Volume of fine aggregates = e x Volume of FA x specific gravity of FA = 0.715 x 0.44 x 2.74 x 1000 = 862 kg

A-9 MIX PROPORTIONS FOR TRIAL NUMBER 1

Cement = 270 kg/m3

Fly ash = 115kg/m3

Water = 140 kg/m3

Fine aggregate = 862 kg/m3

Coarse aggregates = 1097 kg/m3

Chemical admixture = 7.7 kg/m3

Water cement ratio = 0.364

Aggregates are assumed to be in SSD. Otherwise corrections are to be applied while calculating the water content. Necessary corrections are also required to be made in mass of aggregates.

A-10 The slump shall be measured and the water content and dosages ofadmixture shall be adjusted for achieving the required slump based on trials, if required. The mix proportions shall be reworked for the actual water content and checked for durability requirements.

A-11 Two more trials having variation of ± 10 percent of water cement ratio in **A-10** shall be carried out keeping water content constant, and a graph between threewater cement ratios and their corresponding strengths shall be plotted to work out the mix proportions for the given target strength for field trials. However, durability requirements shall be met.

Problem 3

Design of M20 concrete mix as per IS:10262-2009, Concrete mix proportioning-guidelines(First revision)

A-1 Design stipulations for proportioning

i. Grade designation : M20

ii. Type of cement : OPC 43 grade confirming to IS 8112

iii. Maximum nominal size of aggregates : 20 mm

iv. Minimum cement content : 320 kg/m3

v.Maximum water cement ratio : 0.55

vi. Workability : 75 mm (slump)

vii. Exposure condition : Mild

viii. Degree of supervision : Good

ix. Type of aggregate : Crushed angular aggregate

x.Maximum cement content : 450 kg/m3

xi. Chemical admixture : Not recommended

A-2 TEST DATA FOR MATERIALS

p) Cement used : OPC 43 grade confirming to IS 8112

q) Specific gravity of cement : 3.15

r) Specific gravity of

Coarse aggregate :2.68
Fine aggregate : 2.65 s)
Water absorption

Coarse aggregate : 0.6 percent
Fine aggregate : 1.0 percent t)
Free (surface) moisture

Coarse aggregate : Nil (absorbed moisture full)

Fine aggregate : Nil

u) Sieve analysis

Coarse aggregate : Conforming to Table 2 of IS: 383

Fine aggregate : Conforming to Zone I of IS: 383

A-3 TARGET STRENGTH FOR MIX PROPORTIONING

f" ck = fck + 1.65 s

Where

f‘ck = Target average compressive strength at 28 days,

fck = Characteristic compressive strength at 28 days,

s=Standard deviation

From Table 1 standard deviation, s = 4 N/mm2

Therefore target strength = 20 + 1.65 x 4 = 26.60 N/mm2

A-4 SELECTION OF WATER CEMENT RATIO

From Table 5 of IS:456-2000, maximum water cement ratio = 0.55 (Mild exposure) Based on experience adopt water cement ratio as 0.50 0.5 < 0.55, hence ok.

A-5 SELECTION OF WATER CONTENT

From Table-2, maximum water content = 186 liters (for 25mm – 50mm slump range and for 20 mm aggregates) Estimated water content for 75 mm slump = 186 + 3/100 x186 = 191.6 liters

A-6 CALCULATION OF CEMENT CONTENT

Water cement ratio = 0.50

Cement content = 191.6/0.5 = 383 kg/m3 >320 kg/m3(given)

From Table 5 of IS: 456, minimum cement content for mild exposure condition = 300 kg/m3

Hence OK

A-7 PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE

AGGREGATE CONTENT

From Table 3, volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone I) for water-cement ratio of 0.50 =0.60

A-8 MIX CALCULATIONS

The mix calculations per unit volume of concrete shall be as follows

a) Volume of concrete = 1 m3

b) Volume of cement =

= [383.16/3.15] x [1/1000] = 0.122 m3

c) Volume of water = [192/1] x [1/1000] = 0.192 m3

d) Volume of all in aggregates (e) =a – (b + c)
= 1 – (0.122 + 0.192) = 0.686 m3

e) Volume of coarse aggregates = e x Volume of CA x specific gravity of CA = 0.686 x 0.6 x 2.68 x 1000 = 1103 kg

f) Volume of fine aggregates = e x Volume of FA x specific gravity of FA
= 0.686 x 0.4 x 2.65 x 1000 = 727 kg

A-9 MIX PROPORTIONS FOR TRIAL NUMBER 1

Cement = 383
kg/m3 Water =
191.6 kg/m3

Fine aggregate = 727 kg/m3
Coarse aggregates = 1103 kg/m3
Water cement ratio = 0.50
Yield =2404.6 kg

Aggregates are assumed to be in SSD. Otherwise corrections are to be applied while calculating the water content. Necessary corrections are also required to be made in mass of aggregates. Trial mixes: Laboratory study.

Problem 4

Design of M30 concrete mix as per IS:10262-2009, Concrete mix proportioning-guidelines(First revision)

A-1 Design stipulations for proportioning

xii. Grade designation : M30

xiii. Type of cement : OPC 43 grade confirming to IS 8112

xiv. Maximum nominal size of aggregates : 20 mm

xv. Minimum cement content : 350 kg/m3

xvi. Maximum water cement ratio : 0.50

xvii. Workability : 25 - 50 mm (slump)

xviii. Exposure condition : Moderate

xix. Degree of supervision : Good

xx. Type of aggregate : Crushed angular aggregate

xxi. Maximum cement content : 450 kg/m3

xxii. Chemical admixture : Not recommended

A-2 TEST DATA FOR MATERIALS

v) Cement used : OPC 43 grade confirming to IS 8112

w) Specific gravity of cement : 3.15

x) Specific gravity of

Coarse aggregate :
2.68 Fine aggregate :
2.65 y) Water
absorption

Coarse aggregate : 0.6 percent
Fine aggregate : 1.0 percent z)
Free (surface) moisture

Coarse aggregate : Nil (absorbed moisture full)

Fine aggregate : Nil

aa) Sieve analysis

Coarse aggregate : Conforming to Table 2 of IS: 383

Fine aggregate : Conforming to Zone I of IS: 383

A-3 TARGET STRENGTH FOR MIX PROPORTIONING

f‟ ck = fck + 1.65
s Where

f‟ ck = Target average compressive strength at 28 days,
fck = Characteristic compressive strength at 28 days, s=
Standard deviation

From Table 1 standard deviation, s = 5 N/mm2

Therefore target strength = 30 + 1.65 x 5 = 38.25 N/mm2

A-4 SELECTION OF WATER CEMENT RATIO

From Table 5 of IS:456-2000, maximum water cement ratio = 0.50 (Moderate exposure) Based on experience adopt water cement ratio as 0.45 as the cement is 53 grade 0.45 < or =0.5, hence ok.

A-5 SELECTION OF WATER CONTENT

From Table-2, maximum water content = 186 liters (for 25mm – 50mm slump range and for 20 mm aggregates) Estimated water content for 25-50 mm slump = 186 liters

A-6 CALCULATION OF CEMENT CONTENT

Water cement ratio = 0.45

Cement content = 186/0.45 = 413 kg/m3 >350 kg/m3(given)

From Table 5 of IS: 456, minimum cement content for moderate exposure condition = 300 kg/m3

Hence OK

A-7 PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE

AGGREGATE CONTENT

From Table 3, volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone I) for water-cement ratio of 0.50 =0.60. Modify this as w/c is 0.45. The new value is 0.61. Volume of fine aggregate is 0.39.

A-8 MIX CALCULATIONS

The mix calculations per unit volume of concrete shall be as follows

g) Volume of concrete = 1 m3

h) Volume of cement

= [413/3.15] x [1/1000] = 0.131 m3

i) Volume of water = [186/1] x [1/1000] = 0.186 m3

j) Volume of all in aggregates (e) =a – (b + c)
= 1 – (0.131 + 0.186) = 0.683 m3

k) Volume of coarse aggregates = e x Volume of CA x specific gravity of CA = 0.683 x 0.61 x 2.68 x 1000 = 1117 kg

l) Volume of fine aggregates = e x Volume of FA x specific gravity of FA

= 0.683 x 0.39 x 2.65 x 1000 = 706 kg

A-9 MIX PROPORTIONS FOR TRIAL NUMBER 1

Cement = 413 kg/m3

Water = 186 kg/m3

Fine aggregate = 706 kg/m3

Coarse aggregates = 1117 kg/m3

Water cement ratio = 0.45

Yield =2422 kg