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Compressive strength test of the concrete

Objective

To determine the compressive strength of concrete and to check wether the required strength based on design is obtained or not.

Material required

- 28 days cured concrete cube

Apparatus required

- Compressive strength testing machine

Theory

Compressive strength of a concrete is designed as the resistance to withstand compressive load. The compressive strength of concrete is determined to control the quality of concrete and to specify the grade of concrete.

Compressive strength = compressive load / cross-sectional area

Details of cube testing:

- Grade of concrete = M20
- Recommended proportion = 1:2:3
- Size of the cube = 150*150*150 mm
- No of cubes = 3

Observations

a. Combined bending and shear

Cube	Weight (kg)	Failure load (KN)	Avg. compressive load (KN)
1	7.85	400	416.67
2	7.55	420	
3	8.25	430	

b. Flexure

Cube	Weight (kg)	Failure load (KN)	Avg. compressive load (KN)
1	8.4	550	517.33
2	8.55	550	
3	8.35	452	

Area of cube = 150*150 mm^2 = 0.0225 m^2

Calculation

a. **For combined bending and shear**

Average compressive strength = average compressive load/area

=416.67 / 0.0225 = 18518 KN/m^2 = 18.52 MPa

b. **For flexure**

Average compressive strength = 517.33/0.0225 = 22992.59 KN/m^2 = 22.99 MPa

Result

Hence the avg. compressive strength of the cube was found to be 18.52MPa and 22.92MPa respectively for combined bending and shear and flexure conditions.

Comments and conclusions:

The cubes were tested for M20 grade of concrete .The practical value of compressive strength for flexure testing come satisfactory as it exceeds the required value. But, the practical value of compressive strength of the cubes tested for torsion were found quite below the standards. This discrepancy may be due to the improper mixing, casting and curing of concrete. As such the cubes were found to of very low standards than required which show that the concrete mix is improper and can't be used for construction purpose.

Work for nominal mix of the concrete

Objectives

I. To determine the required portion for ingredient of concrete
II. To achieve a concrete which is workable in plastic stage and will develop the required qualities when hardened.

Concrete mix

The proportion of the mix was 1:2:3

Principle

A nominal mix concrete is prescribed concrete. It means a proportional of the ingredients are specified by an engineer without testing the material. The w/c ratio may or may not be specified it is understood that sufficient water will be added to get the proper workability. There is no guarantee that a nominal mix gives the desired strength.

Calculation of the quantities

- Inside length of the mold = 750 mm
- Inside breadth of mold = 150 mm
- Inside depth of mold = 150 mm

∴ Volume of beam = 750*150*150 mm^3 = 0.016875 m^3

Volume of cube = 150*150*150 mm^3 = $3.375*10^{-3}$ m^3

Volume of 3 cubes = 0.010125 m^3

□□ Total volume required = 0.027 m^3

The volume of concrete is increase by 15 %

Hence, ultimate volume of concrete = 0.03105 m^3

Density of concrete = 2500 kg/m^3

□□Weight of concrete = 0.03105*2500 = 77.625 kg

Total part of the mixture = 1+2+3 = 6 part

Weight of cement = 1/6*81 = 12.94 kg

Weight of sand = 2/6*81 = 25.87 kg

Weight of coarse aggregate = 3/6*81 = 38.82 kg

Result

Cement required = 12.94 kg

Sand required =25.87 kg

Aggregate required = 38.82 kg

Obtained proportion by weight = 1:2:3

Conclusions

Thus the proportions of each ingredients of concrete required for the following tests were determined for nominal mix of the M20 concrete:

I. Pure bending
II. Pure shear
III. Combined shear and bending
IV. Splicing

1. Pure bending RC response test

Objective

I. To observe the cracking load and yielding load, ultimate load as well as crack propagation and crushing of concrete at ultimate state.
II. To understand the ductile response of reinforced concrete under monotonic loading.

Theory

As the beam is defined to resist the imposed bending moment when a reinforced concrete beam is subjected to monotonously increased loading, it will go through three distinct stages before it falls completely.

I. Un-cracked stage
II. Cracked stage
III. Ultimate strength stage

Bending cause tension in the portion laying below neutral axis and compression above the neutral axis. Hence the beam is reinforced in the tension side with steel such that the tension force is taken up by the reinforcement during bending. Concrete and steel act simultaneously with increasing load. Tension steel undergoes large plastic deformation while tension force remains constant in steel. This result in increased strain in extreme compression fiber of constant and shifting the neutral upwards the flexural strength of section is reacted when the extreme compression force of concrete attains its ultimate strain.

In limit state method of design, depth of NA is determined from the equation of internal compression and tension force as :

C=T

Or, $0.36\sigma_{ck}b_x = 0.87\sigma_y A_{st}$

Or, $x = 0.87\sigma y Ast/0.36\sigma_{ck}b$

To find moment of resistance of section

a) If $x<x_u$ section is under reinforced

Or, MoR = $(0.36\ f_{ck}\ b\ X_u\ (d-0.416\ X_u\ ) + A_{sc}\ (f_{sc} - f_{cc}\ )\ (d- d^{'})$

b) If $X > X_u$, section is over reinforced

MoR = $0.36\ f_{ck}\ b\ X_u\ (d-0.416\ X_u\ ) + A_{sc}\ (f_{sc} - f_{cc}\ )\ (d- d^{'})$

Materials required:

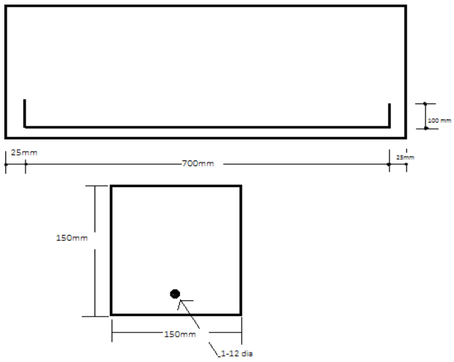
I. Cement
II. Sand
III. Aggregates
IV. Water
V. Steel bars (1-12 mm φ)

Apparatus required:

I. Form water
II. Testing machine
III. Vibrator
IV. Shovels
V. Weighing machine
VI. Hack-saw
VII. Tape

Procedures

I. Formwork was cleaned, prepared and greased.
II. 1-12 mm φ bars was cut to length of 950 mm and edges were bent up to 100 mm
III. The concrete mix was prepared from the calculated amount of cement, sand and aggregate and water in given proportion.
IV. The bottom of the formwork was filled by mix upto 25 mm and then steel bar was placed and then again concrete mix was poured , vibrated and allowed to settle for 24 hours.
V. These cubes 150mm*150mm*150 were also casted simultaneously.
VI. After 24 hours, formwork was removed and beam and cube were cured for 28 days and testing was done in lab.



Observation and calculation:

Preliminary data

Provided length of beam (l) = 750 mm

Breadth of beam (b) = 150 mm

Overall depth of the beam (D) = 150 mm

Effective depth of beam (d) = 119 mm

Dead load of the beam (W) =

Area of the tensile steel (A_{st}) = 113.1 mm^2

Grade of concrete (f_{ck}) = 20 MPa

Grade of steel (f_y) = 415 MPa

Neutral axis (X) = $0.87f_y\ A_{st} /0.36\ f_{ck}\ b$ = 37.81 mm

Critical neutral axis (X_{ul}) = 57.12 mm

Since $X<X_{ul}$,section is under reinforced

MoR = 0.87fy Ast (d-0.416 X_{ul})

=4.22 KNm

Observation data:

Observation data for failure (p) = 20 bar

Load at cracking stage= 55 KN

Moment at mid span =$P(cracking\ load) * l/2$ =15.125 KNm

Result and conclusions:

At the tension side of the beam, nearly vertical cracks were developed which is due to dominance of the bending stress and shear near the mid span of the beam resolving in flexural cracking perpendicular to the axis of the beam. Diagonal shear cracks were seen in mid span of the beam.

The theoretical value of moment of resistance is 4.22 KNm whereas the practical value is 15.125 KNm which is greater than former one.

Combined bending and shear test

Objective

I. To analyze the modes of failure and evaluating loading criteria
II. To compare the theoretical value and experimental value of shear taken by design section
III. To compare the moment of inertia of resistance obtained theoretically and experimentally.

Theory

Shear failure occurs under the combined action of hearing force and bending moments and is characterized by very small deflection and lack of ductility. The failure is sudden and occurs without warning. For this reason, the shear failure is considered by undesirable and is usually avoided as far as possible. Hence it is very important to understand and to analyses the shear failure phenomenon.

Change in bending moment along the span of beam causes the shear stresses and hence shear force. The load at which diagonal crack forms is taken as the strength of the beam in shear. An exact analysis of shear in reinforced beam is quite complex, extensive experimental studies have release that the load carrying diagonal crack is resisted by beam and consist of following components:

I. Shear resisted by the dowel action of the flexural reinforcement known as dowel shear capacity (15-30 %)
II. Shear carried by critical component of interface along the crack due to aggregate interlocking (35-50 %)
III. Shear resisted by under locked concrete in compression (20-40%)

In simple concept, normal shear stress is given by

$T_{uv} = v_u/bd$

Materials required:

I. Cement
II. Sand
III. Aggregate
IV. Water
V. Steel rods
VI. a. 2-4.75 mm φ top bars   b. 2-8.5 mm φ bottom bars

c. 7.75 mm φ vertical stirrups @

Apparatus required:

I. form work
II. testing machine
III. shovel
IV. tamping rods
V. hack saw
VI. tape
VII. bending arrangement

Procedures:

I. Formwork was cleaned and assembled.
II. The formwork was greased uniformly from inside.
III. Steel bars and stirrups were cut and bend as per requirement.
IV. The bars were then fixed accordingly.
V. The concrete mix was then prepared and mixed properly taking the calculated amounts and placed in formwork and tamped with tamping rod.
VI. The work was then allowed to set for 24 hours and then cutting was done for 20 days and testing was done.

Observations and calculations:

- Dimension of the beam =
- Effective depth = 125 mm
- Dead load of the beam =
- Area of the tensile bar = 100.530 mm^2
- Area of the compressive bar = 35.44 mm^2
- Grade of the steel = 415 MPa
- Grade of concrete = 20 MPa
- Percentage of tensile steel = 0.446 %

T_c = 0.48 N/mm^2

- Permissible shear force = 10.8 KN
- Due to vertical stirrups = 15.48 KN
- Total = 26.28 KN

From experiment:

Pressure at which crack started = 251 bar

Experimental shear force = 82 KN

For bending:

$X_u = 0.87 f_y A_{st} – A_{sc} (f_{sc} – f_{cc}) / 0.36 F_{ck} b$

By trial and error ,let’s proceed

$X_{u,l}$ = 0.48*116.25 = 55.8

Now trial ist,

Adopt X_u= $X_{u,l}$ = 55.8

E_{sc} = 0.00148 d' = 25+4.75+4.75/2 = 32.125

F_{sc} = 288.7

F_{cc} = 8.31

X_u = 0.87f_y A_{st} – A_{sc} (f_{sc} – f_{cc})/ 0.36 F_{ck} b = 24.406

A_{st} = 100.53 A_{sc} = 35.441

Trial 2nd

Adopt X_u = 40.103

E_{sc} = 0.000696

F_{sc} = 335 N/ mm^2

X_u = 22.782

By similar process

X_u = 33 < 55.8 hence section is under reinforced

MoR = (0.36 f_{ck} b X_u (d-0.416 X_u) + A_{sc} (f_{sc} – f_{cc}) (d- d') = 4.57 KNm

From experiment:

Load developed at the crack = 82 KN

Actual moment of resistance developed practically = 8.2 KNm

Hence, actual moment developed practically > theoretical moment

Comments and conclusions:

Cracking pattern

The crack was initiated from the lower part of the beam at the certain distance from support and extended from the length. Initially the crack extended vertically and then formed inclined flexural shear crack.

From observed value of cracking it can be said that the failure was due to combination of both shear and flexure. As design value of shear strength and bending moment was very much below, the load applied in beam is safe in both shear and bending.

Due to this reason, the experimental value deviated from the theoretical value.

It may be due to poor quality of sand, cement, aggregate etc. it may be also due to improper mixing and poor workmanship inadequate curing etc.

Bond and anchorage test

Objective

To observe the bond failure pattern in the RC beam

Theory

Laping is done to join two reinforcing bars to form a longer one to develop full strength by bond round the surface so that it doesn't slip under the design stress. The force may be transferred from one bar to another by a lapped or mechanical welded joint. The splicing should be as far as possible away from the section of high stress and where several parallel bars are to be joined, the joints should be staggered. It is recommended that splices in flexural members should not be provided at sections where the BM is more than 50 % of MoR and more than 50 % of total bars shouldn't be joined at one section.

Materials

I. RC beam of 750 mm
II. M20 concrete
III. Fe415 with shear reinforcement

Procedures:

I. Formwork was cleaned, prepared and greased.
II. 2-8 mm φ bars were cut to length of 525 mm and edges were bent up to 100 mm in each bend
III. The overlapping of 150 mm is done so that the two bars combinely acts as a tension bars in bending.
IV. The concrete mix was prepared from the calculated amount of cement, sand,. Aggregates and water in given proportion.
V. The bottom of formwork was filled by mix up to 25 mm and then steel bars was placed and then again concrete mix was poured, vibrated and allowed to settle for 24 hours.
VI. The cubes of size 150*150*150 mm were also casted simultaneously.
VII. After 24 hours formwork was removed and beam and cubes were cured in 28 days and testing was done in a lab.

Shear failure test

Objective

To know about the mode of shear failure in the RC beam

Materials required

I. RC beam of span 750 mm
II. M20 concrete
III. Fe415 with shear reinforcemen

Theory

Shear force is present in beam where there is a change in bending moment along the s pan. It is equal to rate of change of bending moment. An exact analysis of shear in RC concrete beam is quite complex. Several experimental analysis have been conducted to understand the various mode of failure which could occur due to possible combinations of shear and bending moment acting at the given section.

The modes are:

I. Diagonal tension failure
II. Flexural shear failure
III. Diagonal compression failure

Study has shown that shear force is resisted by the un-cracked concrete in compression region. The aggregates interlocking and the shear acting across the longitudinal steel bars. Shear reinforcement if present will also resist shear failure.

Procedures:

I. Formwork was cleaned, prepared and greased.
II. 2-8 mm φ bars and 2-4.750mm φ bars was cut to length of 900 mm and edge were bend up to 100 mm in each end
III. 2-8 mm φ bars were placed at the lower side and 2-4.75 mm φ bars were placed at the top.
IV. 3-4.75 mm φ bars were used for vertical stirrups
V. The concrete mix was prepared from the calculated amount of cement, sand and aggregates and water in given proportion
VI. The steel framework was placed inside the formwork works and was filled by concrete mix by pouring and compacting and allowed to settle for 24 hours.
VII. The 3 cubes of size 150*150*150 mm were also casted simultaneously.
VIII. After 24 hours, formwork was removed and beams and cubes were cured for 28 days and testing was performed on it.

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