# STUDY OF CRACKS AND DEFLECTIONS IN RCC SLAB

Ms.Snehal Ambade, Ms.Shweta Ghormade, Mr.Shubham Naukarkar, Mr.Pratik Thulkar, Mr.Sourabh Sarode

**Civil Engineering Department, KDK College of Engineering, R.T.M. N.U. Nagpur, Maharashtra, India.**

pratik.thulkar@gmail.com
snehal.snohi19@gmail.com

**Abstract – This paper includes the mix design for M30 grade of concrete using super-plasticizer Masterpolyheed 8632 as per IS 10262:2009. The various cracks patterns that occur in slab due to various reasons are also described.**

**Keywords**- Masterpolyheed 8632

## 1. INTRODUCTION

Cracking of concrete will occur whenever the tensile strength of the concrete is exceeded. This is inevitable in normal reinforced concrete structure, and once formed the cracks will be present for the remainder of the structure's life. Because cracks affect the serviceability of a building, the limit state of excessive crack width needs to be considered in design.

Cracking can occur when the slabs are directly loaded. This may be immediately after the temporary props are removed during construction the slabs must support their self weight for the first time. Support settlement is an example of an imposed deformation that tends to cause flexure in a slab. Shrinkage of concrete or temperature changes can cause the occurrence of restrained deformation. These actions can cause significant flexural or direct tensile stresses to develop in the hardened concrete. Reinforcing steel is required in slabs to control cracking under these circumstances.

Following are the causes of cracks and deflection:

1. Permeability of concrete
2. Thermal movement
3. Corrosion of reinforcement
4. Moisture movement
5. Rapid drying of the concrete
6. Creep

## 2. EXPERIMENTAL INVESTIGATION

1. Materials

1.1 Cement :

Ordinary Portland cement (53 Grade) is used. The physical properties of the cement tested according to Indian standards procedure confirms to the requirements of IS 10262-2009 and the physical properties are given in table-

Physical properties of cement:

| Sr. No. | Properties | Result obtained | Standard values |
|---|---|---|---|
| 1. | Standard consistency | 33% | - |
| 2. | Initial setting time (minutes) | 45 min. | Not less than 30 min |

| | | | |
|---|---|---|---|
| 3. | Final setting time (minutes) | 330 min. | Not greater than 600 min |
| 4. | Soundness(mm) | 5 | < 10 mm |
| 5. | Fineness | 9.0% | < 10% |
| 6. | Specific gravity | 3.15 | - |

1.2 Fine aggregates:

The sand conforming to zone II as per IS 383:1970 was used for making reference concrete.

Physical properties of fine aggregate:

| SR. NO. | PROPERTIES | RESULT OBTAINED |
|---|---|---|
| 1. | Type | Natural |
| 2. | Specific gravity | 2.6 |
| 3. | Bulkage | 8.5% |
| 4. | Fineness modulus | 2.48 |
| 5. | Surface texture | Smooth |
| 6. | Particle shape | Rounded |

1.3 Coarse aggregate:

All types of aggregate are suitable. The normal maximum size is generally 10-20 mm. Consistency of grading of vital importance. Coarse aggregate conforming to IS 383:1970.

Physical properties of coarse aggregates (20mm):

| SR. NO. | PROPERTIES | RESULT OBTAINED |
|---|---|---|
| 1. | Type | Natural |
| 2. | Specific gravity | 2.67 |
| 3. | Surface texture | Rough |
| 4. | Particle shape | Angular |

1.4 Super plasticizer:

Name of super plasticizer: Masterpolyheed 8632

| SR. NO. | PROPERTIES | RESULT OBTAINED |
|---|---|---|
| 1. | Aspect | Light brown |
| 2. | pH | ≥6% |
| 3. | Chloride ion content | ≤0.2% |

## 3. MIX DESIGN

The mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible. For proportioning in connection with a concrete mix, four factors are important, namely (a) water/cement ratio, (b) cement content, (c) gradation of aggregates and (d) consistency.

MIX DESIGN FOR M30 GRADE BY INDIAN STANDARD AS PER IS 10262:2009

### A. Stipulations for proportioning

a) Grade designation = M30
b) Type of cement = OPC 53 grade
c) Maximum nominal size of aggregate = 20mm
d) Minimum cement content = 320 kg/m$^3$
e) Maximum water-cement ratio = 0.45
f) Workability = 100mm (slump)
g) Exposure condition = Severe (for reinforced concrete)
h) Type of aggregate = Crushed angular aggregate
i) Chemical admixture type = Super plasticizer

**Table 5 Minimum Cement Content, Maximum Water-Cement Ratio and Minimum Grade of Concrete for Different Exposures with Normal Weight Aggregates of 20 mm Nominal Maximum Size**

(*Clauses* 6.1.2, 8.2.4.1 *and* 9.1.2)

| Sl No. | Exposure | Plain Concrete | | | Reinforced Concrete | | |
|---|---|---|---|---|---|---|---|
| | | Minimum Cement Content kg/m$^3$ | Maximum Free Water-Cement Ratio | Minimum Grade of Concrete | Minimum Cement Content kg/m$^3$ | Maximum Free Water-Cement Ratio | Minimum Grade of Concrete |
| 1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| i) | Mild | 220 | 0.60 | – | 300 | 0.55 | M 20 |
| iii) | Moderate | 240 | 0.60 | M 15 | 300 | 0.50 | M 25 |
| iii) | Severe | 250 | 0.50 | M 20 | 320 | 0.45 | M 30 |
| iv) | Very severe | 260 | 0.45 | M 20 | 340 | 0.45 | M 35 |
| v) | Extreme | 280 | 0.40 | M 25 | 360 | 0.40 | M 40 |

**B. Test data for materials**

a) Specific gravity of

1) Coarse aggregate = 2.6

2) Fine aggregate = 2.67

b) Zone of sand = zone II

**C. Target strength for mix proportioning**

f'ck = fck + 1.65 x 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 =1+5=6 $N/mm^2$

Therefore, target strength = 30+1.65x6 = $39.9 N/mm^2$

**Table 1 Assumed Standard Deviation**
(*Clauses* 3.2.1.2, A-3 *and* B-3)

| Sl No. (1) | Grade of Concrete (2) | Assumed Standard Deviation $N/mm^2$ (3) |
|---|---|---|
| i) | M 10 | 3.5 |
| ii) | M 15 | |
| iii) | M 20 | 4.0 |
| iv) | M 25 | |
| v) | M 30 | 5.0 |
| vi) | M 35 | |
| vii) | M 40 | |
| viii) | M 45 | |
| ix) | M 50 | |
| x) | M 55 | |

NOTE — The above values correspond to the site control having proper storage of cement; weigh batching of all materials; controlled addition of water; regular checking of all materials, aggregate grading and moisture content; and periodical checking of workability and strength. Where there is deviation from the above, values given in the above table shall be increased by 1 $N/mm^2$.

**D. Selection of water-cement ratio**

From table 5 of IS 456, Maximum water-cement ratio = 0.45

Based on experience, adopt W/C ratio = 0.4

0.45> 0.4, hence OK

**E. Selection of water content**

From table 2, maximum water content = 186 litre (for 25 to 50 mm slump range)

For 20 mm aggregate

Estimated water content for 100mm slump =186+0.06x186 = 197.16 liters.

As super-plasticizer is used, the water content can be reduced up 20 percent and above.

The water content = 197.16x0.8= 158 liter

**Table 2 Maximum Water Content per Cubic Metre of Concrete for Nominal Maximum Size of Aggregate**
(*Clauses* 4.2, A-5 *and* B-5)

| Sl No. (1) | Nominal Maximum Size of Aggregate mm (2) | Maximum Water Content [1)] kg (3) |
|---|---|---|
| i) | 10 | 208 |
| ii) | 20 | 186 |
| iii) | 40 | 165 |

**F. Calculation of cement content**

Water cement ratio = 0.4

Cement content = (158/0.4) = 395 $kg/m^3$.

From table 5 of IS 456:2000, minimum cement content for 'severe' exposure condition= 395 $kg/m^3$ > 320 $kg/m^3$, hence, OK.

**G. 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 II) for water-cement ratio of 0.50 = 0.62. In the present case water-cement ratio is 0.4. Therefore, volume of coarse aggregate is required to be increased to decrease the fine aggregate content. As the water-cement ratio is lower by 0.10, the proportion of volume of coarse aggregate is increased by 0.02 (at the rate of -/+ 0.01 for every ± 0.05 change in water- cement ratio). Therefore, corrected proportion of volume of coarse aggregate for the water-cement ratio of 0.62+0.01

Volume of coarse aggregate content = 0.63

Volume of fine aggregate content = 1-0.63= 0.37m$^3$

**Table 3 Volume of Coarse Aggregate per Unit Volume of Total Aggregate for Different Zones of Fine Aggregate**

(*Clauses* 4.4, A-7 *and* B-7)

| Sl No. | Nominal Maximum Size of Aggregate mm | Volume of Coarse Aggregate[1] per Unit Volume of Total Aggregate for Different Zones of Fine Aggregate | | | |
|---|---|---|---|---|---|
| | | Zone IV | Zone III | Zone II | Zone I |
| (1) | (2) | (3) | (4) | (5) | (6) |
| i) | 10 | 0.50 | 0.48 | 0.46 | 0.44 |
| ii) | 20 | 0.66 | 0.64 | 0.62 | 0.60 |
| iii) | 40 | 0.75 | 0.73 | 0.71 | 0.69 |

[1] Volumes are based on aggregates in saturated surface dry condition.

### H. Mix calculations

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

a. Volume of concrete = 1 m$^3$

b. Volume of cement

$$= \frac{Mass\ of\ cement}{sp.gr.of\ cement} \times \frac{1}{1000}$$

$$= \frac{395}{3.15} \times \frac{1}{1000} = 0.125m^3$$

c. Volume of water

$$= \frac{Mass\ of\ water}{sp.gr.of\ water} \times \frac{1}{1000}$$

$$= \frac{158}{1} \times \frac{1}{1000} = 0.158\ m^3$$

d. Volume of Chemical Admixture ( 1% of cementitious material )

$$= \frac{Mass\ of\ admixture}{sp.gr.of\ admixture} \times \frac{1}{1000}$$

$$= \frac{3.95}{1.145} \times \frac{1}{1000} = 0.00345\ m^3$$

e. Volume of all aggregate

= (a - (b + c + d ))

= (1- (0.125+ 0.158 +0.00345))

= 0.714 m$^3$

f. Mass of Coarse aggregate

= *e* x Volume of coarse aggregate x sp. gr. of coarse aggregate x 1000

= 0.714 x 0.63 x 2.67 x 1000

= 1201.02 kg.

g. Mass of Fine aggregate

= *e* x Volume of fine aggregate x sp. gr. of fine aggregate x 1000

= 0.714 x 0.37 x 2.6 x 1000

= 686.87 kg.

**Obtained mix proportion:**

| Water / cement ratio | Cement | Sand | Coarse aggregate |
|---|---|---|---|
| 0.4 | 395 kg. | 686.87 kg. | 1201.02 kg. |
| | 1 | 1.74 | 3.04 |

## 4. TEST RESULT

Dimensions:

Cubes = (150x150x150) mm

Beam = (500x100x100) mm

Cylinder = 150mm diameter, 300 mm long

| SR. NO. | LOADING ON | 3 DAYS | 7 DAYS | 14 DAYS | 28 DAYS |
|---|---|---|---|---|---|
| 1 | Cube (Tonne) | 45<br>47<br>44 | 62<br>58<br>60 | 70<br>72<br>68 | 91<br>89<br>92 |
| | Compressive strength (N/mm$^2$) | 19.76 | 26.16 | 30.52 | 39.5 |
| 2 | Beam (kg) | 460 | 600 | 770 | 890 |
| | Flexural strength (N/mm$^2$) | 2.71 | 3.54 | 4.52 | 5.25 |
| 3 | Cylinder | 20 | 27 | 32 | 40 |

| | | | | | |
|---|---|---|---|---|---|
| | (Tonne) | | | | |
| | Split tensile strength ($N/mm^2$) | 2.77 | 3.73 | 4.44 | 5.55 |

## 5. Cracks in slab

Concrete inherits certain type of cracks in pre-hardening stage and also develop some other types of cracks in post hardening stage in due course of time due to various reasons, despite our utmost care in prevention of cracks. While concrete becomes older, these cracks become sources of leakages and seepages and give easy access to the moisture, oxygen, chloride, carbon dioxide, and other aggressive chemical leading to serious degradation of the structure and causing corrosion of steel and damage in the concrete and subsequently causing structural failure of the member.

**Types of cracks:**

Following are the various types of cracks occur in the slab along with their causes and their significance to the structure.

1. Plastic shrinkage cracks: Cracks that run to the mid-span of the concrete, are distributed across the surface unevenly, and are usually short in length.
It most often occurs while concrete is curing, due to the surface of the concrete drying too rapidly relative to the concrete below.

**Fig. Plastic shrinkage cracking**

2. Map cracking: A web of fine, shallow cracks across the surface of the concrete.
   It also occurs during curing due to the surface of the concrete drying faster than the interior concrete, but the surface drying occurs at a lesser depth.
   Because this type of cracking is limited to the surface, it does not usually pose serious structural problems.

**Fig. Map cracking**

3. Hairline cracking: These are very thin but deep cracks.
   These occur due to settlement of concrete while it is curing. Due to their depth, these cracks can allow for more serious cracking once the concrete once the concrete is hardened.

4. Pop-outs: These are the conical depression in the concrete surface.
   It occurs when a piece of aggregate near the concrete surface is particularly absorbent, causing it to expand and pop out of the surface of the concrete.

**Fig. Pop- outs**

5. Scaling: These are the small pock marks in the concrete surface, exposing aggregate underneath.
   Once cured, if concrete does have an adequate finish to prevent water penetration, water that seeps into the concrete will expand when it freezes, pushing off pieces of concrete surface.
   Scaling can also be caused by delamination, which occurs when too much water or air remains in the concrete when it is finished. The water and air rise to the top and form pockets below the surface. These pockets may form blisters or which may break open to create scaling.

**Fig. Scaling**

6. Spalling: These are surface depressions that are longer and deeper than scaling, often linear when following the length of a rebar.
   These are also caused by pressure from under the surface of the concrete. These most often occur due to improperly constructed joints or the corrosion of rebar in the concrete.
   Spalling that exposes corroded metal can be particularly problematic because the corrosion is likely to accelerate due to exposure to air and water.

**Fig. Spalling**

7. Diagonal corner cracking: Cracks that run from one joint to its perpendicular joint at the corner of a slab.
   The corners of concrete slabs can be prone to curling or warping. The dryer or colder level of

concrete will shrink more and create cracks as the concrete dries.

Because the warped or curled up corners often have some empty space below them, they are also prone to cracking after curing due to weight overload causing the corner to snap downward into the empty space.

## 6. REFERENCE


1. Concrete Technology by M. S. Shetty.
2. Specification for Coarse and Fine Aggregates from Natural Sources for Concrete. IS 383-1970 Bureau of Indian Standards, New Delhi.
3. Code of Practice for Plain and Reinforced Concrete. IS 456-2000, Bureau of Indian Standards, New Delhi.
4. Methods of Sampling and Analysis of Concrete. IS 1199-1959, Bureau of Indian Standards, New Delhi.
5. IS 10262: 2009, “Guidelines for Concrete Mix Design Proportioning”, Bureau of Indian Standards, New Delhi.
6. IS 2386: 1963, “Methods of test for Aggregates for Concrete”, Part I & III, Bureau of Indian Standards, New Delhi.
7. IS 516:1959, “Methods of Tests for Strength of Concrete”, Bureau of Indian Standards, New Delhi
8. “Identifying Cracks in Slabs”. Concrete Construction. July 31, 2014.