Good Practices in Building Construction

Presentation By

S.Satheesh Kumar,
University Engineer,
Kerala University of Health Sciences,
Thrissur.

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PLEASE MUTE OR TURN OFF YOUR MOBILE PHONE

When we build

- When We build,let us think we build for ever
- Let it not be for the present delight
- Nor for the present use alone
- Let it be such work as our di descendants will thank us for

-John Ruskin

Safety

- Responsibility of contractor and engineer
- Personal Safety equipments
- Caution boards
- Ribbons
- Lighting
- Wardens

QUALITY OF WORKMANSHIP

- ***When defects in brickwork are pointed out to a mason, he will say that the defects will be covered in the plastering.***

- ***When there are defects in plastering, he will say that they will be covered in painting.***

- ***There is no short cut to good Workmanship.***

ALIGNMENT OF BUILDING

DESIGN AND LOCATION TO BE APPROVED BY THE CLIENT DEPARTMENT

- **ARRANGE SUFFICIENTLY EARLY SHIFTING OF UTILITIES, CUTTING OF TREES DEMOLITION etc.**
- **APPLY FOR SANCTIONS FROM LOCAL BODIES(CHECK SET BACKS,FAR,COVERAGE etc)**
- **IDENTIFY SOURCE FOR WATER,APPLY FOR POWWER CONNECTION**

SITE LEVELLING

- **LEVEL OF ADJACENT ROAD**
- **ACCESS**
- **NEIGHBOURING BUILDINGS**
- **CELLAR FLOOR**
- **PARKING AREA**

EARTH WORK

- **DEPTH OF FOUNDATION (depends on…….)50-80Cm**
- **LINE AND LEVEL**
- **BEARING CAPACITY**
- **BOTTOM OF TRENCH SHALL BE LEVELLED BOTH LONGITUDANALLY AND TRANSVERSELY OR STEPPED**
- **ALL LOOSE AND SOFT MATERIAL REMOVED,SOFT AND WEAK SPOTS SHALL BE DUG OUT AND FILLED UP WITH LEVELLING CONCRETE.**

EXCAVATION

- **BEFORE FOOTING IS LAID THE SURFACE SHALL BE SLIGHTY WATERED AND RAMMED.ANY EXCESS DEPTH SHALL BE MADE GOOD WITH THE MIX USED FOR BED CONCRETE**
- **SAFETY SHOULD BE ENSURED.**
- ***THE VALUE OF HUMAN LIFE IS GREATER THAN THE VALUE OF WHAT IS CONSTRUCTED INSIDE THE EXCAVATION*.**
- **RESPONSIBILITY OF CONTRACTOR TO ENSURE SAFETY OF WORKERS & RESPONSIBILITY OF ENGINEER AND CONTRACTOR THE SAFETY OF WORKER AND PUBLIC.**

FOUNDATION CONCRETE

- **UNIFORM THICKNESS AND LEVEL**
- **PERFECT COMPACTION**
- **GRADATION OF BROKEN STONE**
- **SUFFICIENT CURING**

RANDOM RUBBLE MASONRY

CONSTRUCTED WITH STONES AS THEY COME FROM THE QUARRY.

IMPLEMENTS REQUIRED FOR THE MASON?

RR (Contd)

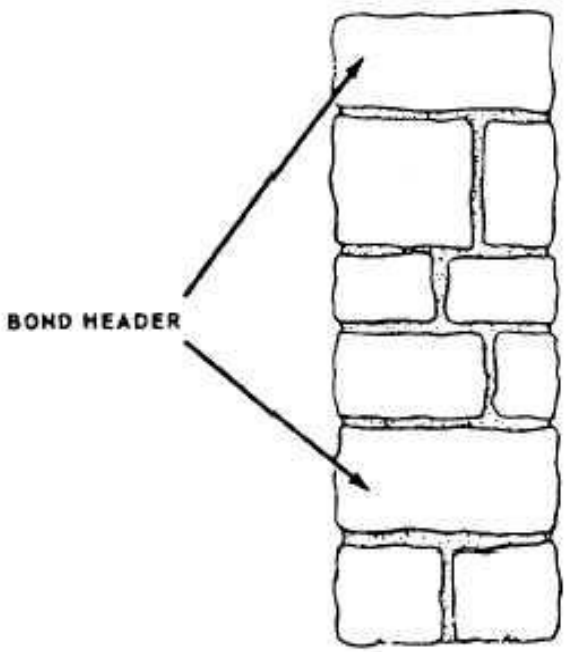
SIZE OF STONE- LENGTH SHALL NOT EXCEED 3 TIMES THE HEIGHT AND BREADTH ON BASE SHALL NOT EXCEED ¾ THE THICKNESS OF WALL NOR LESS THAN 15 CM.THE HEIGHT OF THE STONE SHALL BE UPTO 30 CM

- STONE SHOULD BE HARD,FREE FROM WEATHERING,CRACKS,PATCHES OF SOFT MATERIALS etc.WATER ABSORPTION SHALL NOT EXCEED 5%.
- STONES SHOULD BE WETTED BEFORE USE.
- STONES TO BE PROPERLY SEATED USING HAMMER
- CHIPS NOT EXCEEDING 20% OF THE VOLUME OF MASONRY TO USED FOR FILLING JOINTS

RR (Contd)

- BOND STONES- RUNNING RIGHT THROUGH THE THICKNESS OF WALL-SINGLE STONE FOR THICKNESS UPTO 60 CM.-A SET OF 2 OR MORE BOND STONES OVERLAPPING BY AT LEAST 15 CM IN OTHER CASES.
- ONE BOND STONE FOR EVERY 2.0M2 OF AREA OF WALL SURFACE
- PRECAST CONCRETE BLOCKS OF 1:3:6 OF CROSS SECTION NOT LESS THAN 225CM2 AND LENGTH EQUAL TO THICKNESS OF WALL CAN BE USED AS BOND STONES.
- DURING INSPECTION WALK OVER THE CONSTRUCTION TO VERIFY THE STONES ARE PROPERLY SEATED.

RR Contd.



Cement Mortar

- NEVER ALLOW TO PREPARE MORTAR OVER BARE GROUND
- ENSURE CORRECT PROPORTION AND THOROUGH MIXING BEFORE ADDING WATER-EVEN USE MIXER MACHINE FOR MIXING(DON'T ADD WATER)
- SIEVED AND GOOD SAND
- ENSURE REQUIRED QUANTITY OF WATER IS ADDED TO THE CEMENT/SAND MIX AND THE MORTAR IS FULLY UTILISED BEFORE THE STARTING OF INITIAL SETTING TIME
- SEE THAT PREVIOUS DAY'S MORTAR IS NOT USED NEXT DAY.

NECESSITY FOR MORTAR

The way the **mortar is prepared** and used determines the final strength achieved.

Basement filling

- PREFERABLY RED EARTH
- CLAYEY SOIL AND DELETERIOUS AND ORGANIC MATERIALS, VEGETATIONS AVOIDED
- DONE IN LAYERS OF 15 cm, WATERED AND RAMMED WITH RAMMERS OR BUT END OF CROWBARS
- TOP 30 cm ,PREFERABLY WITH SAND OR GRANULAR MATERIAL TO CONTROL DAMPNESS.

Damp proofing Course

- Rise of moisture from the ground by cappilary action
- DPC Course with RCC –mini thickness-15cm
- Sand layer under base concrete
- Bituminous felt
- Sandwiching bituminous membrane between two layers of concrete.

DPC (contd…)

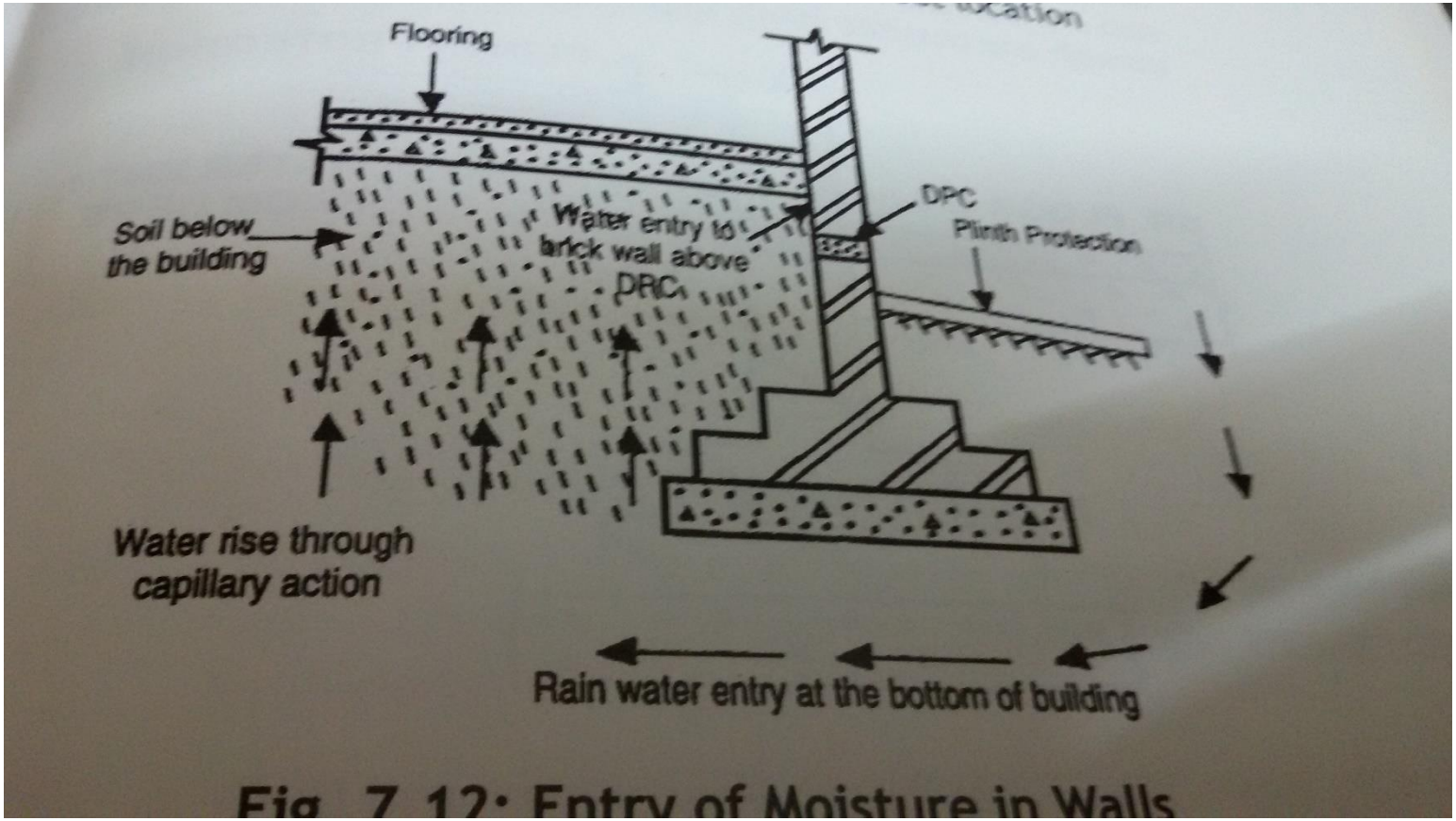


Fig. 7.12: Entry of Moisture in Walls

DPC(contd…..)

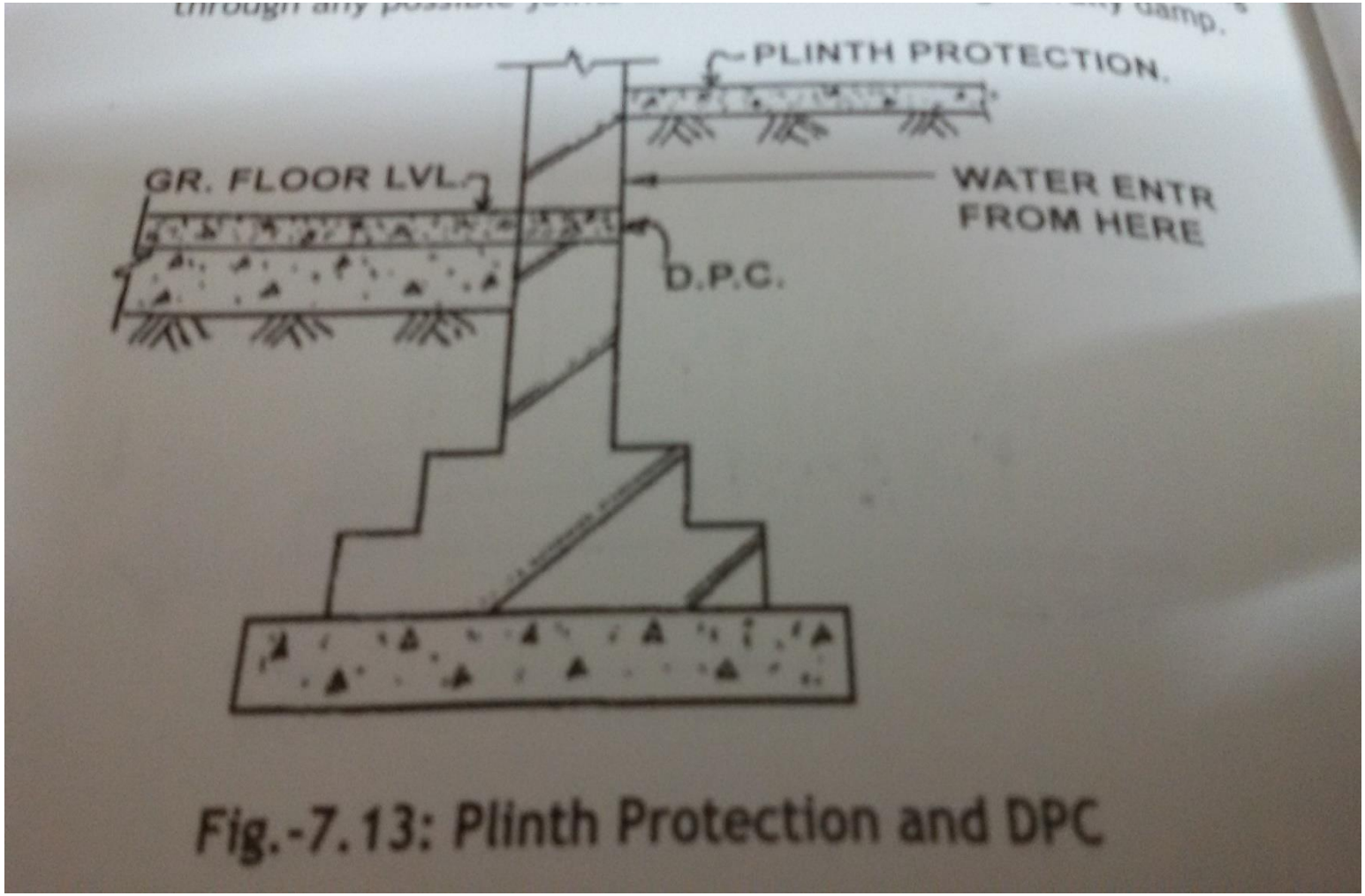


Fig.-7.13: Plinth Protection and DPC

DPC(contd….)

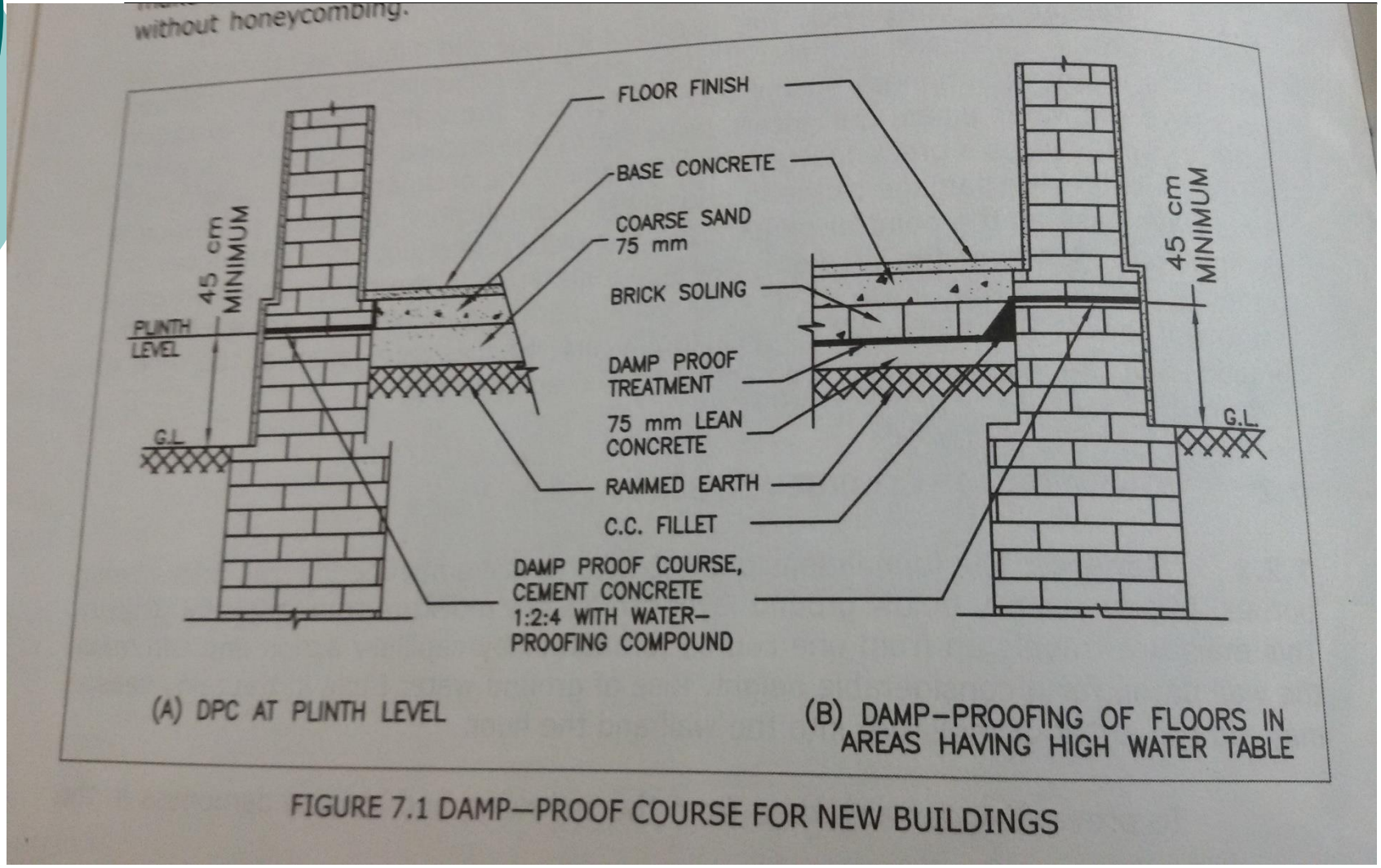


FIGURE 7.1 DAMP–PROOF COURSE FOR NEW BUILDINGS

CHARACTERISTICS OF GOOD QUALITY BRICKS

- Good bricks should be **hard, sound and well burnt.**
- **Two sizes-modular and non modular**
- **Compressive strength-7N/mm2**
- Should give a **metallic ringing sound** when struck with another brick or with a hammer.
- Should have **uniform colour** and fine compact texture.
- When **dropped from a height of one meter** on another brick, it **should not break.**
- **should not absorb water more than 20 percent** of its own weight.

CHARACTERISTICS OF GOOD QUALITY BRICKS

- Should be free from water soluble chlorides or sulphates. Source of salts could be from the soil or from the water used for brick making.

A good brick of 2 kg should not weigh more than 2.4 kg if immersed in water for 24 hours

IDENTIFICATION OF UNDER-BURNT BRICKS

- If soaked in water for few hours, half-burnt bricks will weather easily **(the surface can easily be scratched with finger nails)**.

- Hence **soaking** the bricks for a **minimum of one hour** before using will ensure that under-burnt bricks are not used for construction.

NEED FOR A "FROG"

- The indent or sinking in the brick is termed a frog.
- Some bricks have no indent or frog at all, some have on one face only and some have indents on both long faces.
- They are formed to facilitate the bedding of bricks in mortar.
- **All bricks should be placed with their frogs on top so as to provide good bonding with mortar.**

Brick Masonry(Contd)

THE MORTAR SHALL BE PROPERLY MIXED-EXCESSIVE W/C RATIO MAY REDUCE THE STRENGTH OF MORTAR BY HALF

SUCTION RATE OF BRICKS HAS A PRONOUCED EFFECT ON STRENGTH OF MASONRY-BE CAREFUL.

STRENGTH OF MASONRY REDUCES ON INCREASE OF THICKNESS OF BED MORTAR-10MM.INCREASE IN THIHNESS BY 3MM REDUCES STRENGTH BY 15%.

INADEQUATELY FILLED VERTICAL JOINTS LOWER RAIN RESISTING PROPERTY OF WALL.

Contd…

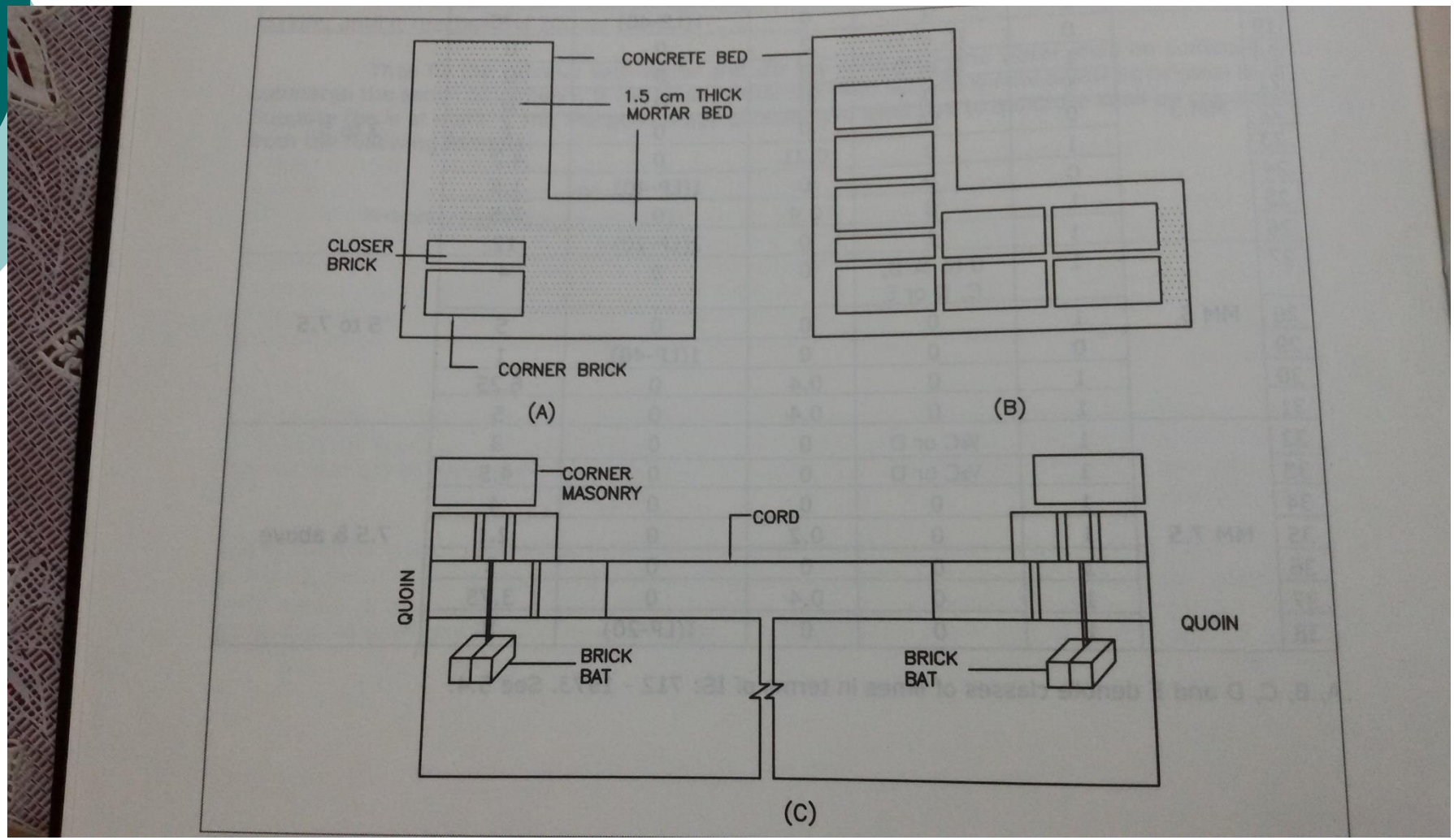
- CURING SHALL BEGIN AS SOON AS PARTIAL SET OF MORTAR HAS TAKEN PLACE.
- IN HOT WEATHER CURING SHALL COMMENCE AFTER 12 HOURS AND IN COLD WEATHER AFTER 24 HOURS.
- CURING FOR 7 DAYS,3 TIMES DAILY.

FOR MULTISTORIED FRAMED STRUCTURE THE CONSTRUCTION OF MASONRY PANELS/WALLS SHALL COMMENCE FROM ??????

DISTURBANCE OF BRICKS AFTER LAYING AFFECTS BOND STRENGTH &SHEAR STRENGTH .

ENSURE PLUMB AND STAGGERED VERTICAL JOINTS AND CURING.

Brick laying



Concrete Block Masonry

- EXTENSIVELY USED NOW A DAYS.
- REGULAR IN SHAPE AND SIZE,HENCE RAPID CONSTRUCTION.
- FEWER JOINTS-SAVINGS IN MORTAR AND INCREASED STRENGTH.
- TRUE PLAIN SURFACES OBVIATING NECESSITY OF PLASTERING.
- SHRINKAGE MORE FOR CONCRETE BLOCKS.HENCE BLOCKS SHALL BE ALLOWED TO COMPLETE INITIAL SHRINKAGE BEFORE LAID IN A WALL.
- THE CONCRETE BLOCKS SHALL BE DRIED FOR A PERIOD OF 4 WEEKS AFTER IT'S CASTING AND CURING, BEFORE BEING USED FOR A WORK

shrinkage

- Most of the building materials having pores in their structure expand on absorbing moisture and shrink on drying.These movements are reversible/cyclic.
- Apart from this all cement based materials undergo some irreversible movement due to drying out of moisture used in their manufacture.

Shrinkage (contd…)

Initial shrinkage of concrete and mortar occurs only once in the life time, i.e. at the time of manufacture/construction, when the moisture used in the process of manufacture/construction dries out.

- The initial drying shrinkage of concrete/mortar far exceeds the reversible movement due to subsequent wetting/drying.
- 1/3 shrinkage in first 10 days,1/2 within one month and remaining in about an year.

Scaffolding

- TEMPORARY STRUCTURES ERECTED TO SUPPORT LABOUR AND MATERIALS.
- SHALL BE PROPERLY CONSTRUCTED.
- SIZE OF POLES-MEAN DIA 8CM AND MINI. DIA 5CM-.L/D RATIO NOT GREATER THAN 50.SPACING OF POLES 1 TO 1.2M-VERTICAL SPACING OF LEDGERS(HORIZONTAL BRACING) SHALL NOT EXCEED 1.8 M.
- BRACING IN LONGITUDINAL AND TRANSVERSE DIRECTION.

Concrete

SUPERVISION

"IT IS EXCEEDINGLY DIFFICULT TO ALTER CONCRETE ONCE PLACED. HENCE CONSTANT AND STRICT SUPERVISION OF ALL ITEMS OF THE CONSTRUCTION IS NECESSARY DURING THE PROGRESS OF WORK INCLUDING THE PROPORTIONING AND MIXING OF CONCRETE. THE SUPERVISION IS ALSO OF EXTREME IMPORTANT TO CHECK THE REINFORCEMENT AND ITS PLACING BEFORE BEING COVERED".

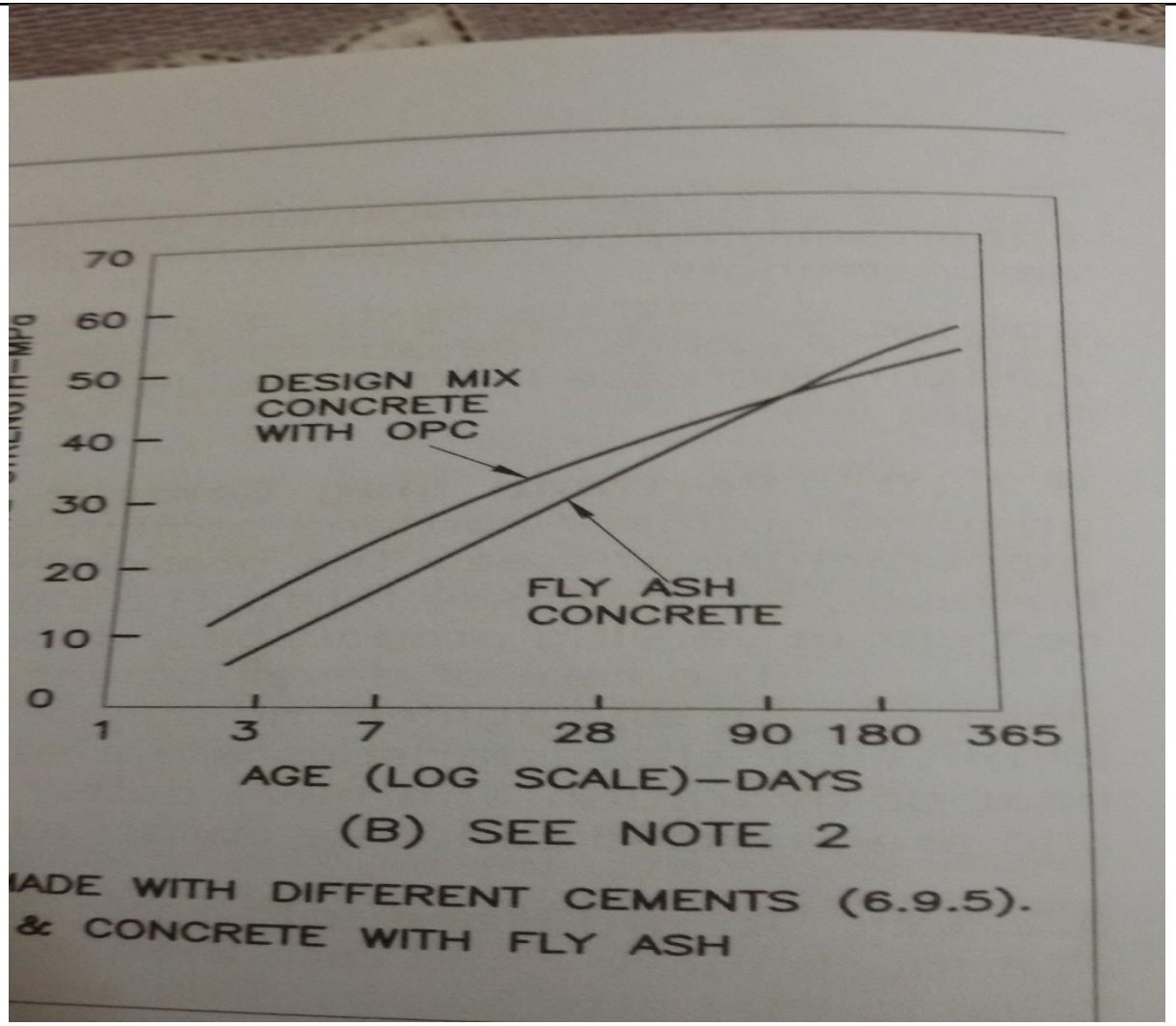
Concrete

Ph value of Concrete ?

- TYPES OF CEMENT- BY ADJUSTMENT IN RELATIVE PROPORTIONS OF CHEMICAL COMPOUNDS AND FINENESS
- OPC 33(28 DAYS COMP.STRENGTH NOT LESS THAN 33N/mm2-70.6mm SIZE CEMENT MORTAT CUBES 1:3,MADE UNDER CONTROLLED TEST CONDITIONS)
- OPC 43(28 DAYS COMP.STRENGTH NOT LESS THAN 43N/mm2)
- OPC 53(28 DAYS COMP.STRENGTH NOT LESS THAN 53N/mm2-
- MORE FINELY GROUND)
- PPC(BLENDED CEMENTS-FLY ASH BASED AND SLAG BASED)

Concrete(Contd)

- FLY ASH (COAL INDS.) CONTENT NOT LESS THAN 15% AND NOT GREATER THAN 35%-COLLECTED BY ELECTROSTATIC PRECIPITATORS-ENVIORNMENTAL CONCERNS
- PORTLAND SLAG CEMENT-STEEL INDUS.-CONTENT 25% TO 65%-RATE OF DEVELOPMENT OF EARLY STRENGTH SLOWER-LOWER HEAT OF HYDRATION AND BETTER SULPHATE RESISTANCE.
- BLENDED CEMENT REQUIRE LONGER PERIODS OF WET CURING AND RATE OF STRENGTH GAIN IN INITIAL STAGES IS SLOWER
- INCREASE IN STRENGTH AFTER 28DAYS WILL BE RELATIVELY HIGH FOR BLENDED CEMENT


70
60
50
40
30
20
10
0
DESIGN MIX CONCRETE WITH OPC
FLY ASH CONCRETE
1
3
7
28
90
180
365
AGE (LOG SCALE)—DAYS
(B) SEE NOTE 2
ADE WITH DIFFERENT CEMENTS (6.9.5).
& CONCRETE WITH FLY ASH

HYDRATION PROCESS

Major Compounds

- Tricalcium silicate, $3Cao.Sio_2$ - **C_3S**
- Dicalcium silicate $2Cao.Sio_2$ - **C_2S**
- Tricalcium aluminates $3Cao\ Al_2o_3$ - **C_3A**
- Tetracalcium aluminoferrite $4Cao\ Al_2o_3\ fe_2o_3$ - **C_4AF**

Concrete (Contd..).field test of cement

- COLOUR-UNIFOR GREY
- FEEL SMOOTH WHEN TOUCHED OR RUBBED BETWEEN FINGERS
- WHEN HAND IS INSERTED INTO A BAG OF CEMENT SHOULD FEEL COOL
- SMALL QUANTITY OF CEMENT THROWN IN A BUCKECT SHOULD SINK,NOT FLOAT.
- FREE FROM LUMPS
- BRIQUETTES MADE WITH C.M 1:6(75X25X12mm),IMMERSED IN WATER FOR 3 DAYS WILL NOT BE BROKEN EASELY AND WILL BE DIFFICULT TO CONVERT TO POWDER FORM
- INSPECT THE COVER BAG

Cement-reduction of strength

Period of storage of cement	Reduction in strength at 28 days
Fresh	0%
1months	10%
2months	15%
3months	20%
6months	35%

Concrete (Contd..)

- Aggregates
- Fine aggregate – particle size between 0.075mm and 4.75mm
  Coarse aggregate – size larger than 4.75 mm

- OCCUPY 90-95% VOLUME OF CONCRETE-CONTRIBUTES CONSIDERABLY TO STRENGTH AND SRUCTURAL PROPERTIES,HENCE BE WATCHFUL.
- COMBINING COURSE AND FINE AGGREGATES IN CORRECT PROPORTIONS,A CONCRETE WITH VERY FEW VOIDS OR SPACES CAN BE MADE

  AGGREGATES SHALL BE
- 1.PROPERLY GRADED (MIXING OF SINGLE SIZE AGGR.)
- 2.SHALL NOT CONTAIN DELETERIOUS MATERIALS AND MATERIALS THAT MAY ATTACK STEEL
- 3. STRENGTH OF THE AGGRGATE SHALL BE HIGHER THAN THAT OF THE CONCRETE MADE WITH THEM.

Types of aggregates

Natural	Manufactured/processed
Dug from a pit or solid	obtained by quarrying
dredged from river	rock & crushing to
suitable	
Eg.gravel, sand	size and grading

Coarse aggregate – Gravel and crushed rock aggregate

Fine aggregate – River sand, manufactured sand

Concrete(Contd..)

- **CRUSHING STRENGTH |**
- **|ASSESSING THE STRENGTH**
- **CRUSHING VALUE |**
- **HARDNESS AND ABRATION RESISTANT(LOS ANGELES TEST) important for concrete exposed for wearing eg. roads,runways**
- **PARTICLE SIZE AND SHAPE AND TEXTURE**
- **WELL ROUNDED REQUIRE LESS WATER &CEMENT PASTE**
- **ELONGATED AND FLAKY NOT DESIRABLE-LOWER WORKABILITY**
- **TEXTURE-ROUGH SURFACE PREFACED-INCREASE BOND AND MORE FLXURAL AND COMP. STRENGTH.**
- **POROSITY AND ABSORPTION**

Aggregate quality

- Clay,dust,silt or mud in aggregate reduces strength
- Dust & grit portions of aggregate will cause an increase in water demand
- The maximum quantity of deleterious materials in coarse and fine aggregates (crushed or natural) shallnot exceed the limits specified in clause3.21 of I.S.383- 1970

Graded coarse aggregate

% passing by weight for nominal size of

IS Sieve Designation	40mm	20mm	16mm	12.5mm
63mm	100	-		
40mm	95 to100	100		
20mm	30 to 70	95 to100	100	100
16mm	-	-	90 to100	-
12.5mm	-	-	-	90 to100
10mm	10 to35	25 to55	30 to70	40 to85
4.75mm	0 to5	0 to10	0 to10	0 to10
2.36mm	-	-	-	-

Table 1 : Limits of Deleterious Materials

(Clause 3.21 of IS:383-1970)

Sr. No	Deleterious substances	Method of test	Fine aggregate percentage by weight, max		Coarse aggregate percentage by weight, max	
			uncrushed	crushed	uncrushed	crushed
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(i)	Coal and lignite	Is: 2386 (Part II) - 1963	1.00	1.00	1.00	1.00
(ii)	Clay lumps	Is:2386 (Part II)- 1963	1.00	1.00	1.00	1.00
(iii)	Materials finer than 75-micron IS Sieve	IS:2386 (Part I)- 1963	3.00	15.00	3.00	3.00
(iv)	Soft fragments	IS:2386 (Part II)- 1963	-	-	3.00	-
(v)	Shale	IS:2386 (Part II)- 1963	1.00	-	-	-
(vi)	Total of percentages of all deleterious materials (except mica) including Sr.No. (i) to (v) for col. 4, 6 and 7 and Sr.No. (i) and (ii) for col. 5 only	-	5.00	2.00	5.00	5.00

Flaky aggregates – Least dimension is less than 3/5 of its mean dimension

Elongated aggregates – Length is 1.8 times its mean dimension

- Rounded shape has minimum surface area for the same mass and therefore requires minimum cement for bonding
- Flaky and elongated shapes have larger surface area for the same mass as compared to rounded or cubical shapes and hence water demand is high
- Concrete produced using flaky and elongated aggregates are prone to segregation, will have poor surface and will have high cement and sand demand
- Natural sand after screening and washing are the best aggregates for concrete

SIZE OF AGGREGATES

THE COMP. STRENGTH CF CONCRETE INCREASES WITH THE DECREASE OF SIZE OF AGGREGATE.(SMALLER PRESENT LARGER SURFACE AREA.STRESS CONCENTRATION IN MORTAR-AGGREGATE INTERFACE INCREASES WITH SIZE)

- Maximum size of C.A. shouldnot be greater than one fourth of the minimum thickness of the member
- For most work, 20mm size is the most suitable
- When there is no restriction to flow of concrete, size upto 40mm may be used
- In concrete element with thin sections,10mm maximum size shall be used
- Plums above 160mm and upto any reasonable size may be used in plain concrete works upto a maximum limit of 20% by volume of concrete

Specific gravity

- Specific gravity of aggregate generally is indicative of its quality
- Low specific gravity indicates high porosity and therefore poor durability and low strength.The range of specific gravity for aggregates is generally between 2.4 and 2.9

Moisture content,absorption and porosity

- Natural aggregates contain moisture – to be considered in mix design
- Porous aggregates will absorb moisture or water than dense aggregates
- If absorption is more, concrete loses workability

Bulking of sand

Presence of moisture in sand causes film of water around sand particles,Due to surface tension causing increase in volume

- For a moisture content of 2-5 percent,increase in volume may be as high as 15 to 30 percent
- Finer the material, more will be the increase in volume for a given moisture content
- When moisture content is increased by adding more water,sand particles pack near each other and the amount of bulking of sand is reduced
- Dry sand and sand completely flooded with water will have practically the same volume

Grading of aggregates

Grading is particle size distribution of aggregate, measured by sieve analysis

- Grading is a major factor which influences workability of fresh concrete and its consequent degree of compaction
- Incomplete compaction results in voids,thereby lowering density of concrete and preventing it from achieving its full compressive strength
- Presence of too much of fines is undesirable as durability and impermeability of concrete is affected
- Hence aggregates shall be well graded.

Table 2 : Grading Limits for Fine Aggregates (IS :383-1970)

IS Sieve	Equivalent BS Sieve	Percentage passing for			
		Zone 1	Zone 2	Zone 3	Zone 4
10 - mm	3/8 - in	100	100	100	100
4.75 - mm	3/16 - in	90-100	90-100	90-100	95-100
2.36 - mm	No. 7	60-95	75-100	85-100	95-100
1.18 - mm	No. 14	30-70	55-90	75-100	90-100
600 - micron	No. 25	15-34	35-59	60-79	80-100
300 - micron	No. 52	5-20	8-30	12-40	15-50
150 - micron	No. 100	0-10	0-10	0-10	0-15

Table shows that Zone I sand is the coarsest and Zone 4 sand is the finest.Sand in Zones II&III are moderate

- For coarse sand,water requirement will be less and for fine sand, water requirement will be more
- Coarse sand willnot impart cohesiveness, which in turn would cause seggregation and bleeding
- Fine sand will impart good cohesiveness, but needs more water for good workability
- Coarse sand will not give good finish whereas fine sand gives good finish to the structure

Storage of aggregates

While storing aggregates,it shall be ensured that they donot get contaminated with dust,mud and soil

- Aggregates must be stored on hard surface so that they donot mix with the soft materials at base
- If hard layer is not available or put at bottom, nearly 30 cm thick bottom portion would be wasted or has to be washed before use in mortar or concrete
- Store differently graded aggregates separately so that mixing donot take place
- Ensure that the aggregates stored are not contaminated with mud and other materials from surface water during rainy season

SILT TEST FOR NATURAL SAND

- I.S.Code prescribes permissible silt content by weight
- However, silt content determination by volume is much simple and can be performed easily at site
- A 250ml glass measuring cylinder is filled with salt water upto 50 ml mark
- Add sand until level of sand is upto 100ml mark
- Add further salt water till 150ml mark is reached
- Place palm on the mouth and shake vigorously
- Place cylinder on hard level surface,tap alround so that sand is levelled
- Wait for 3hours for silt to settle on top of sand
- Measure thickness of silt layer and height of sand
- Silt% by volume=thickness of silt/ht. of sand x 100

  The silt content shallnot exceed 8% after 3 hours

WATER

Water has significant role to play in the making of concrete – in mixing of fresh concrete and curing of hardened concrete

- For proper strength and durability of concrete,water used for mixing and curing shall be free from impurities such as oils,acids,alkalis,salts,sugar and organic materials
- Water suitable for human consumption ie., **potable water** is generally considered to be suitable for concreting
- When potability of the water is suspect,it is advisable to perform chemical analysis of water as per IS3025

ADMIXTURES

- Admixtures are additives which are introduced in a concrete mix to improve properties of concrete in fresh and hardened states
- Admixtures if used shall comply with I.S.9103
- Admixtures shallnot impair durability of concrete nor combine with the constituent to form harmful compounds
- Large no. of proprietary products are available in the market.Their desirable & undesirable effects need to be examined scientifically before they are advocated
- Plasticizers are extensively used as admixtures in concrete works to improve workability& reducing water content

Admixtures are generally added to achieve the following

In fresh concrete

- Increase workability without increasing W/C ratio
- Improve cohesiveness,thereby reducing seggregation and bleeding
- Improve set retardation

Admixtures

- Cebex 100-Plasticising agent and a gas producing expansion medium-compensates for plastic shrinkage.
- BPCIA-KP 200-Bipolar concrete penetrating corrosion inhihiting admixture-Protection of reinforcement against chlorides.

Concrete Mix	Cement Content (Kg/M^3)	W/C	Slump (mm)	Strength (Kg/cm^2) at	
				7 days	28 days
Reference mix without Plasticizer	440	0.37	25	390	540
Mix with Plasticizer	440	0.37	100	411	541

Concrete Mix	Cement Content (Kg/M^3)	W/C	Slump (mm)	Strength (Kg/cm^2) at	
				7 days	28 days
Reference mix without Plasticizer	315	0.60	95	218	291
Mix with Plasticizer	315	0.53	90	285	375

Concrete Mix	Cement Content (Kg/M^3)	W/C	Slump (mm)	Strength (Kg/cm^2) at	
				7 days	28 days
Reference mix without Plasticizer	460	0.43	100	320	420
Mix with Plasticizer	395	0.43	100	336	435

Water content & workability

- Workability – property of freshly mixed concrete(or mortar) which determines the ease and homogenity with which it can be mixed,placed,compacted and finished
- Good workabilty is required for removing entrapped air by minimum effort of compaction
- Main factor influencing workability is water content
- Amount of water required for lubrication depends on the aggregate type,texture and grading
- Finer aggregates require more water to wet their larger specific surface
- Angular aggregates require more water than rounded ones of the same size
- Aggregates with greater porosity consume more water from the mix
- Finer the cement,greater the need for water

Workability is required for full placement of concrete and full compaction,minimising voids in concrete

- Workability depends on water cement ratio
- I.S. code recommends that workability of concrete shall be controlled by direct measurement of water content in the mix
- For this, workability should be checked by slump or compacting factor tests
- Slump test is the simplest and done at the site
- In the test,the distance that a cone full of concrete slumps down is measured when the cone is carefully lifted from around it
- Slump can vary from zero for dry mixes to complete collapse for very wet and lean mixes

Values of workability of concrete

Placing Conditions	Degree of Workability	Slump(mm)
a) Blinding concrete,(b)Shallow sections c)Pavements using pavers	Very low	-
a) Mass concrete,(b)Lightly reinforced sections in slabs,beams,walls ,columns(c)Floors,(d)Hand placed pavements,(e)Canal lining,(f) Strip footing	Low	25-75
a) Heavily reinforced sections in slabs,walls,beams,columns(b) Slip formwork,(c)Pumped concrete	Medium	50-100 75-100
a)Trench fill,(b) In situ piling	High	100-150
a)Tremie concrete	Very high	--

WATER TO CEMENT RATIO

- Ratio of mass of free water(excluding that absorbed by aggregates) to that of cement
- Water cement ratio determines strength, durability and permeability of concrete
- In practice, the ratio lies between 0.35 & 0.65
- For hydration,requirement of W/C is only 0.25
- Compressive strength of hardened concrete is inversely proportional to W/C
- Reduction in W/C improves strength, density, impermeability and reduces shrinkage& creep

ROLE OF W/C

Strength

- Compressive strength is inversely proportional to strength
- Strength for a given W/C vary due to following
  - Changes in aggregate size,grading,surface texture,shape, strength and stiffness
  - Type of cement
  - Type of admixture used
  - Entrapped air content
  - Length of curing time

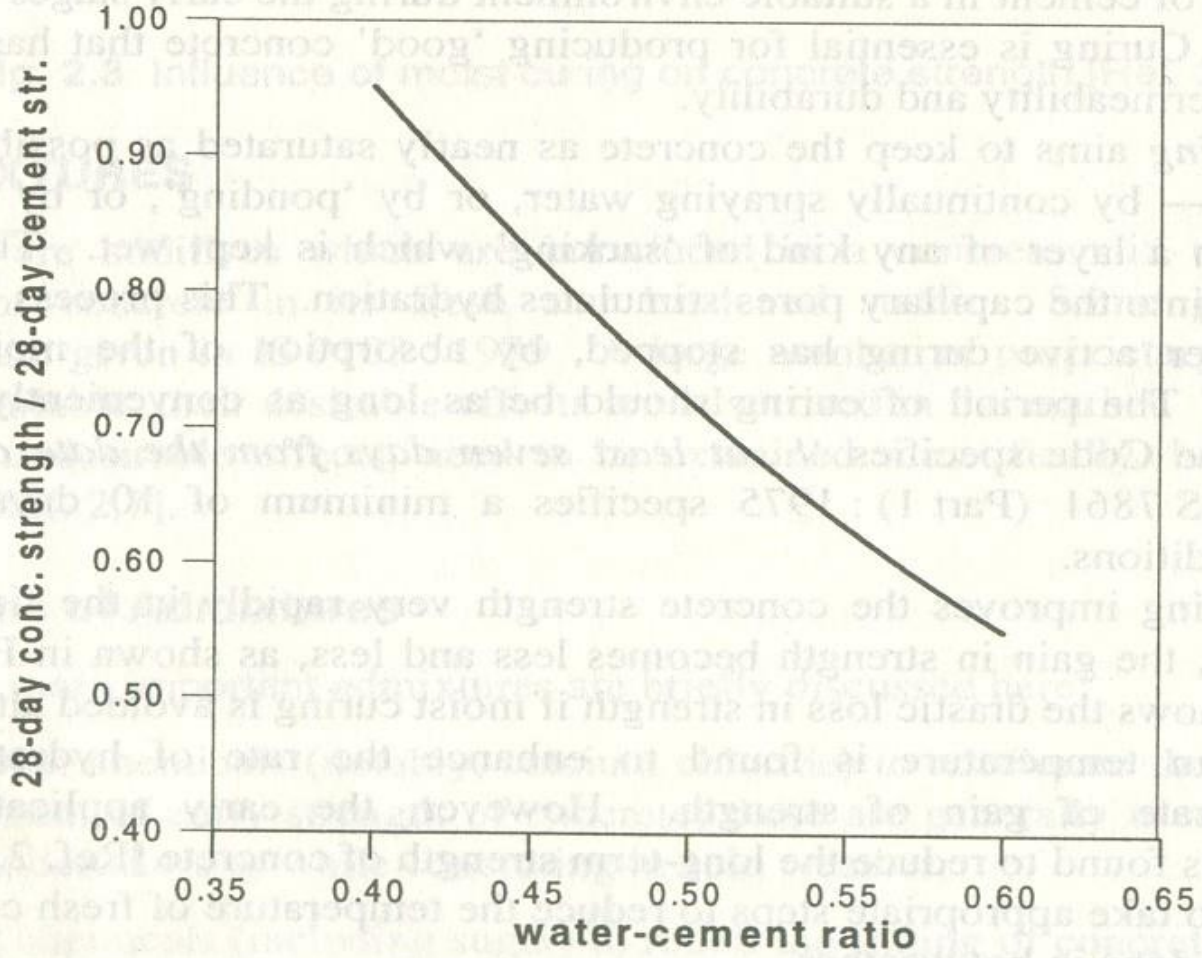


Fig. 2.2 Relation between water-cement ratio and compressive strength [Ref. 2.5]

Role of w/c

Durability

- W/C ratio governs the porosity of the hydrated cement paste and hence relevant to many aspects of durability

  W/C ratio alone doesnot determine durability .The following factors also contribute:
- Voids in concrete as a whole and not in the cement paste(other voids being honeycombs,entrapped air,cracks etc.,)
- Extent of connectivity between the pores that determine the penetrability of the aggressive agents ie., chlorides, sulphates, carbondioxide etc.,)

Role of W/C

PERMEABILITY

Permeability of concrete is of fundamental importance especially when there is possibility of penetration of potentillly aggressive chemicals such as water,chlorides, sulphates and carbon dioxide.

Hydrated cement and water paste has very fine pores Around 0.015 micron and they occupy 28% by volume of cement paste.These [pores are extremely fine and hence impermeable.

Capillary pores are larger and have diameter upto 5 Microns and occupy 40% by volume of total cement paste

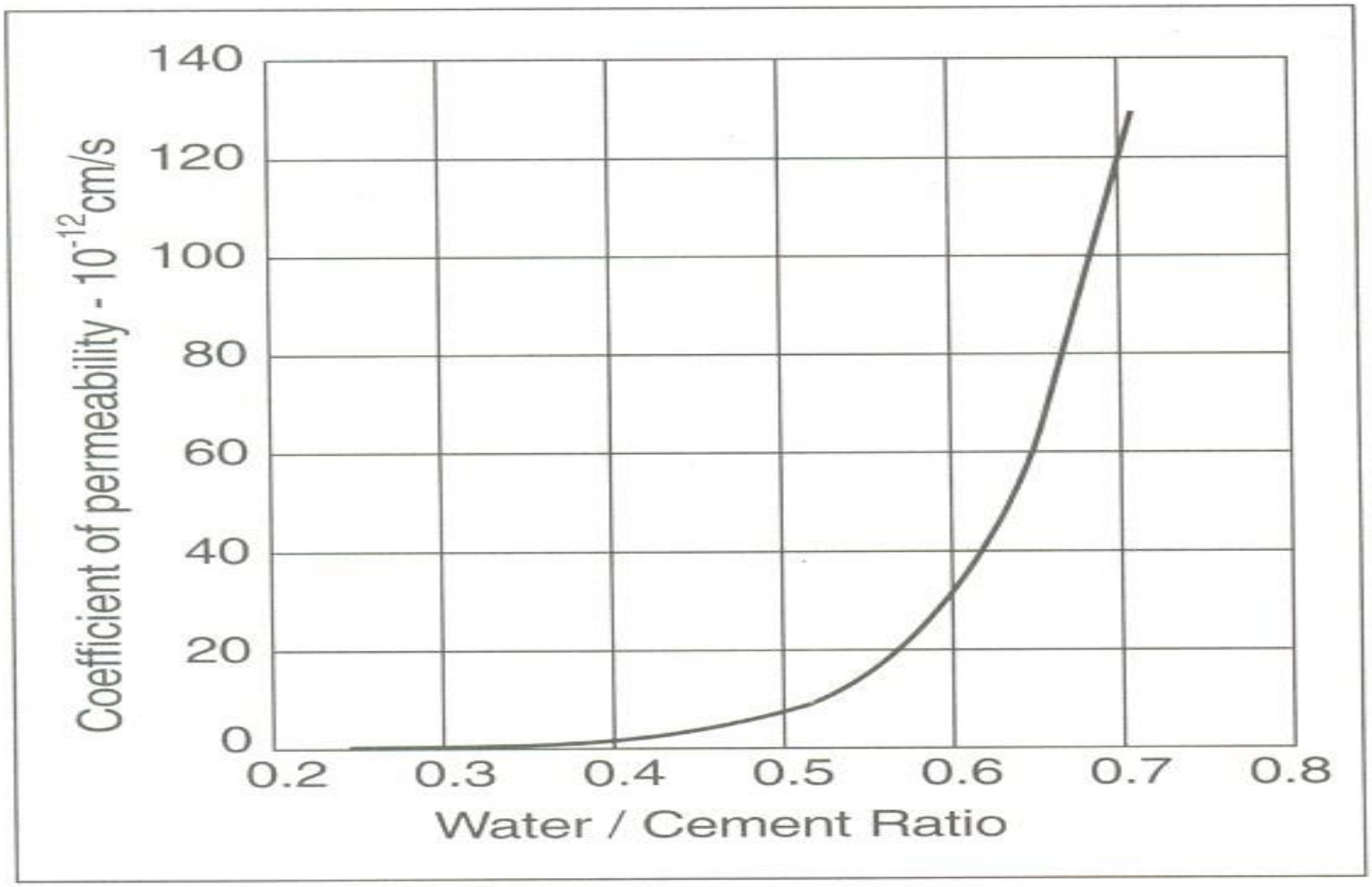


Figure 6 : Example of the relation between permeability water/cement ratio for mature cement paste (93% of the cement hydrated)

Cover

- Minimum cover to be ensured.
- Footings-50mm
- Columns-40mm
- Thin colmns(mini.dimension less than 200mm)-25mm
- Slabs- 20-25mm.
- Cover ensures durability.prevents spalling.

Cover contd…

- Cover delays carbonation(calsium hydrate liberated during hydration.This reacts with CO2 forming calcium carbonate,resulting in shrinkage cracks.Rate of penetration of carbonation-7 to 10mm /decade)

Reasons for poor quality of concrete

- Grade of cement
- Grading of aggregate
- W/C ratio
- A/C ratio
- Shape
- Surface texture
- Water absorption
- Bulking of sand

Reasons for poor concrete

- Mix design
- Preparation of concrete
- Transportation
- Form work
- Placing
- Raw materials
- Compaction
- Curing
- Finishing

Batching of concrete ingredients

Batching is an important part of concrete manufacture as it affects property of concrete in plastic and hardened stages

TYPES

Random volumetric batching with absolute no control on size and shape of containers.Cement is batched assuming each bag contains 50 kg.

Proper volumetric batching of all ingredientss, using measured boxes and with control of filling them to brim and levelling

Proper weighing is done of all ingredients using a weigh batcher

Mixing

- Mixing is an important factor concrete manufacture as it affects properties in the plastic and hardened stages
- Workability, cohesiveness & homogenity in plastic stage is decided by the efficiency in mixing
- Strength, durability, surface finish and texture also depend on mixing
- Manual mixing
- Machine mixing – mixers and batching plant(COURSE,FINE,CEMENT,WATER)
- Machine mixing time – At least 2 minutes as per I.S.
- Mixing time less - mix willnot be uniform & consistent
- Mixing more than required – segregation and reduced workability

Placing of concrete

Deposit concrete at or near its final position

- Place concrete in uniform layers so that seggregation doesnot take place.In column and walls, layer thickness shall be limited to 450 mm while placing
- No restriction for height if mix is cohesive and dropped through a tremie or chute.If fall is free of tremie or chute, segregation takes place.Height has to be limited in this case.
- Segregated mix due to bad placing cannot be compacted

Placing of concrete

- Before placing each layer the previous layer must be fully compacted
- Provide adequate seperators (top &bottom reinforcements)
- Provide wooden planks or catwalks resting on centering.No walking over the reinforcement.
- Avoid displacement of reinforcement and formwork
- Care during rainy season.

Concrete compaction

- Compaction contributes to durability, strength and finish
- Compaction removes entrapped air present in concrete after it is mixed, transported and placed
- Compaction also eliminates stone pockets and thereby all types of voids
- Amount of entrapped air is related to workability
- Lower the workability, higher is the percentage of entrapped air
- That means stiff mix contains more entrapped air and needs more compaction than workable mixes

Methods of compaction

- Rodding– requires sincere manual effort
- Tamping
- Vibration –method prefered for high quality works
- On vibration,concrete mix gets fluidized and internal friction between aggregate particles reduces, resulting in entrapped air rising to the surface
- For stiff mix, compaction to be done for longer period
- For lean or wet mix,compaction effort required is less
- Types – Internal vibrators & external vibrators
- Poker type
- Form vibrators & vibrating tables

Use of a Poker type vibrator

- Insert poker quickly & allow it to penetrate by own weight so that entrapped air is removed uniformly
- Leave poker in concrete for about 10 seconds. The time may vary based on slump
- The effective range of action may taken as 10 times the diameter of the needle.
- Poker insertion shall be quick, but withdrawal shall be slow so that hole left by poker is filled up(80mm/second)
- Poker shall be inserted vertically

Needle vibrator(contd…)

- Location of poker insertion shall be staggered to ensure that every bit of concrete is compacted.
- On heaped concrete, poker shall not be introduced in the centre of heap. Position should be gradually from the side & moving away from heap alround.
- Poker shall extend about 100mm into previous layer
- The vibrator shall not be used for moving concrete laterally, since it will result in segregation.
- Keep enough spare pokers

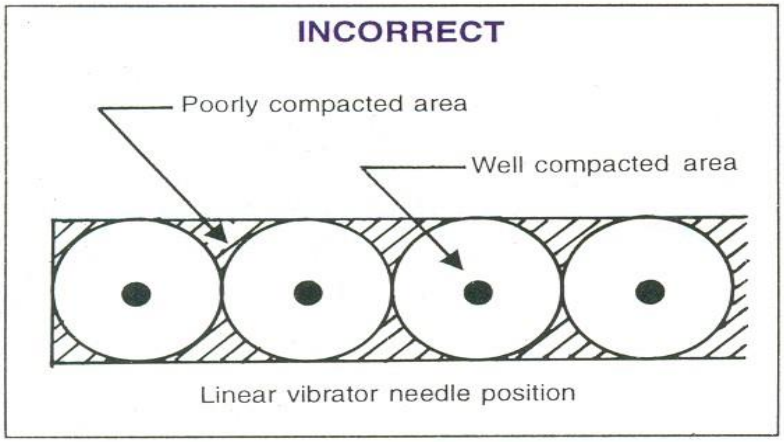


Figure 14 : The incorrect method of poker insertion leaves some areas uncompacted or poorly compacted.

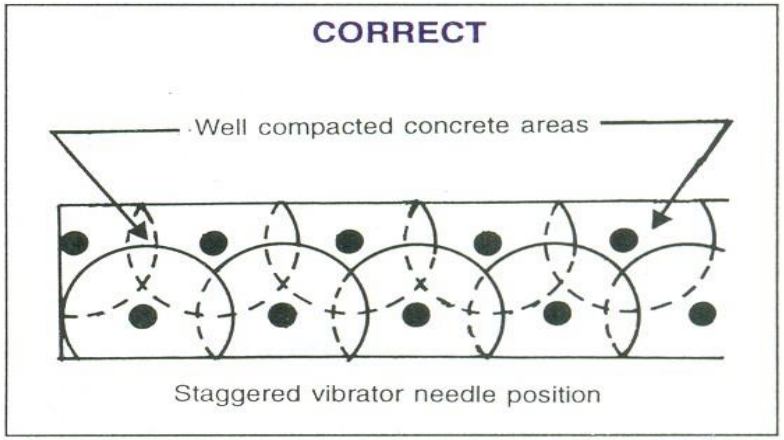
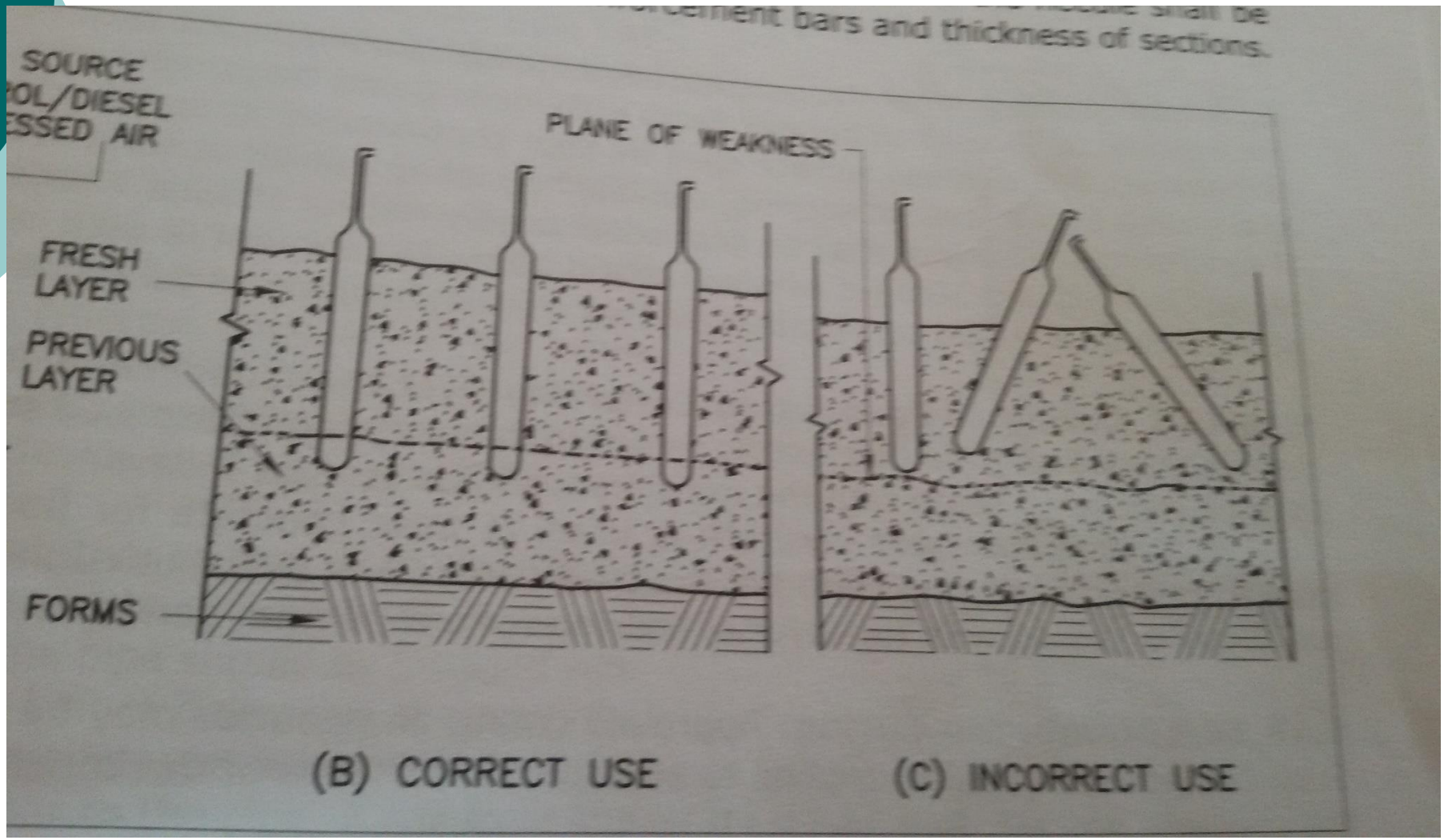


Figure 15 : The correct method of poker insertion results in fully compacted concrete.


SOURCE
OL/DIESEL
SSED AIR
PLANE OF WEAKNESS
FRESH
LAYER
PREVIOUS
LAYER
FORMS
(B) CORRECT USE
(C) INCORRECT USE

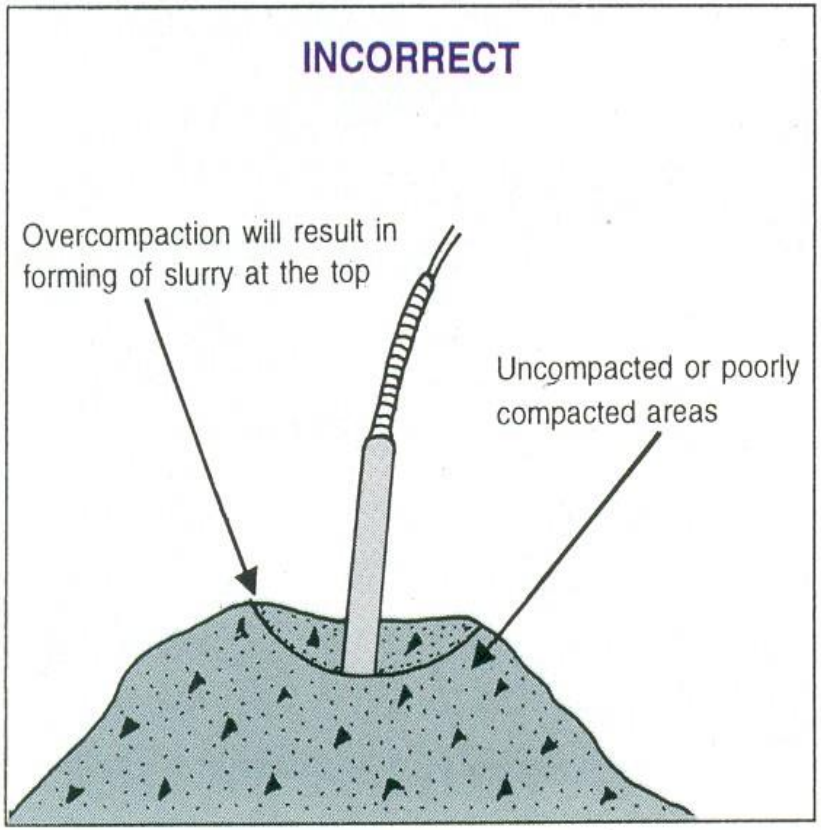


Figure 16 : Incorrect method compaction in a heaped up concrete.

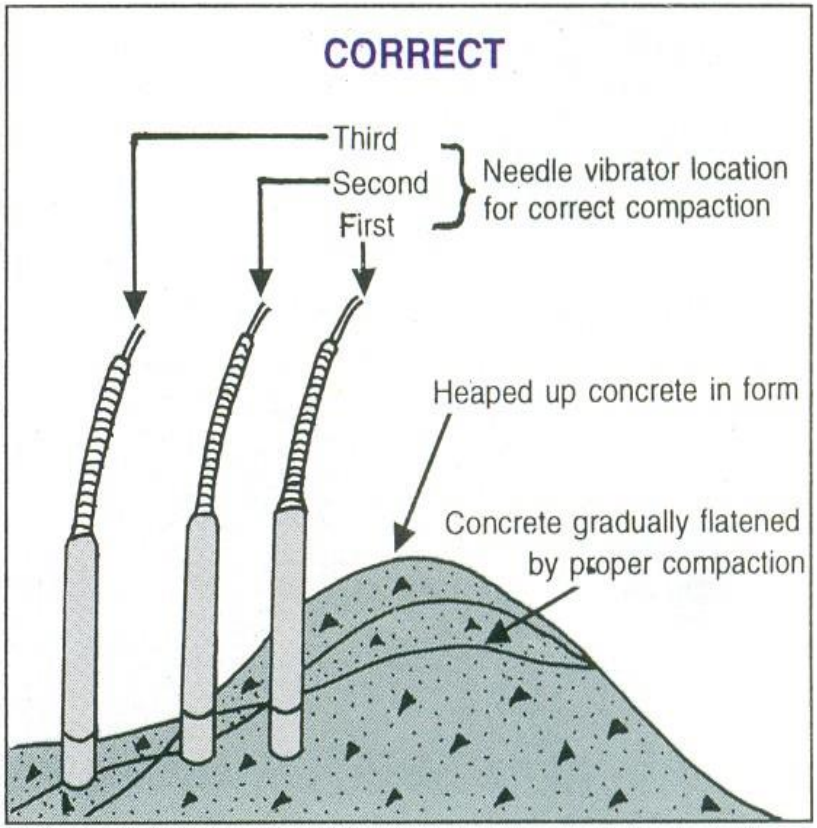


Figure 17 : Correct method compaction in a heaped up concrete.

Duration of compaction

- Matter of judgement and feel of concrete compaction
- As soon as entrapped air bubbles stop emerging, it is understood that compaction is complete
- When the pokers pitch becomes constant, concrete is compacted.A skilled operator can easily make out fro the sound emitted by the vibrator

Compaction (contd…)

A thin film often appears on the concrete surface or from between the formwork and concrete indicating that concrete is fully compacted.

- Over vibration results in seggregation
- If poker is unable to sink by own weight or if poker leaves a hole when withdrawn slowly,it means that initial setting of concrete has begun

Use of a Poker type vibrator

Insert poker quickly & allow it to penetrate by own weight so that entrapped air is removed uniformly

- Leave poker in concrete for about 10 seconds. The time may vary based on slump
- Poker insertion shall be quick, but withdrawal shall be slow so that hole left by poker is filled up
- Poker shall be inserted vertically

Compaction (contd..)

- Location of poker insertion shall be staggered to ensure that every bit of concrete is compacted.
- On heaped concrete, poker shallnot be introduced in the centre of heap.Position should be gradually from the side & moving away from heap alround.
- Poker shall extend about 100mm into previous layer
- Keep enough spare pokers

CURING

Concrete attains strength by hydration of cement for which water has to be present

- Cement hydration rapid in first few days of placing
- Curing – Process of preventing loss of moisture from concrete while maintaining satisfactory temperature
- Curing is essential for achieving strength, impermeability and durability

Curing (contd…)

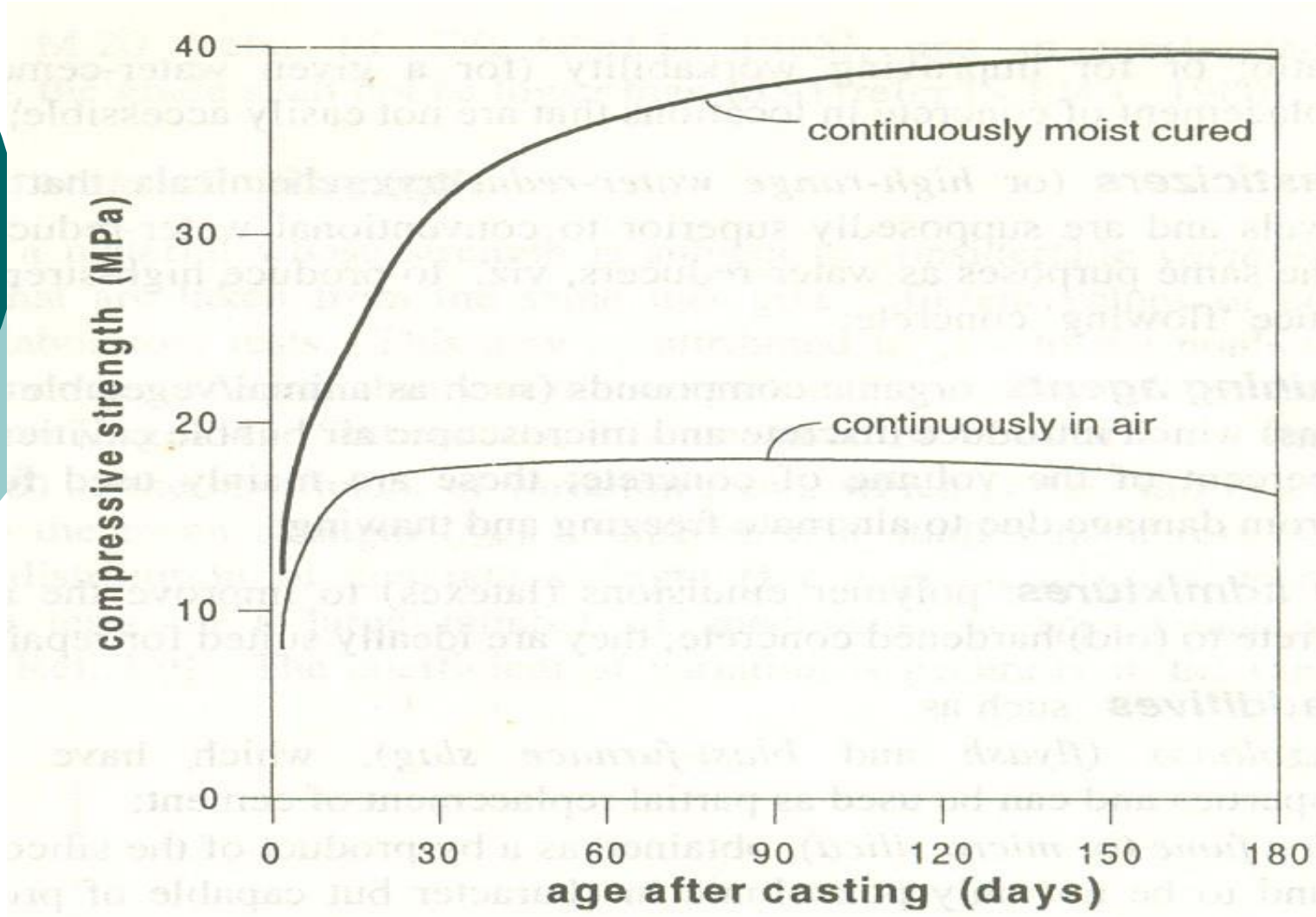
Moist curing – Exposed surfaces shall be kept continuosly in a damp condition by ponding, spraying,covering with a layer of sacking or canvas

Minimum 7 days for OPC under normal weather

Minimum 10 days for OPC exposed to hot weather

Minimum 14 days for blended cement or when admixtures are used

- Membrane curing – Curing compounds may be used soon after concrete has set



g. 2.3 Influence of moist curing on concrete strength [Ref. 2.6]

Role of voids

Voids reduce strength of concrete.1% entrapped air reduces strength by 5 to 6 %. 5% entrapped air means 30% loss of strength

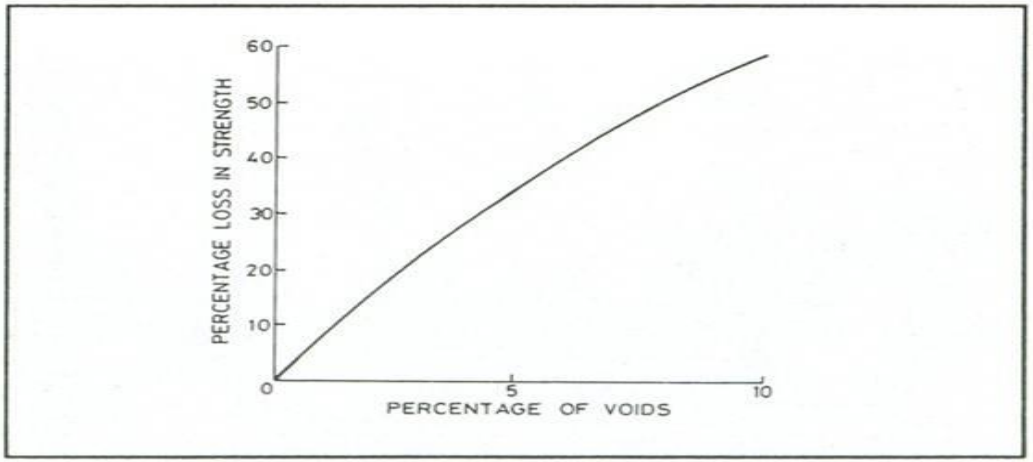


Figure 1 : Typical relation between loss of strength and air voids in concrete.

Role of voids contd.

- Voids increase permeability of concrete. Easy passage of moisture, oxygen, chlorides & other aggressive chemicals occurs. This causes rusting of steel, spalling of concrete and thereby durability

- Easy entry of sulphates causes expansive reaction with C3A.This causes disintegration of concrete.

Role of voids(contd..)

- Entry of carbondioxide causes carbonation of concrete ie., loss of alkalinity or loss of protective power that concrete gives to reinforcement. This results in rusting of steel with entry of moisture
- Voids reduce contact between embedded steel and concrete. Results in loss of bond strength

RESUMING WORK ON A HARDENED SURFACE

SUCH SURFACE SHALL BE ROUGHENED. IT SHALL THEN BE SWEPT CLEAN AND THOROUGHLY WETTED. FOR VERTICAL JOINTS NEEDS CEMENT SLURRY SHALL BE APPLIED ON THE SURFACE BEFORE IT IS DRY. FOR HORIZONTAL JOINTS THE SURFACE SHALL BE COVERED IN THE SAME RATIO AS THE CEMENT AND SAND IN THE CONCRETE MIX. THE CEMENT SLURRY OR MORTAR SHALL BE FRESHLY MIXED AND APPLIED IMMEDIATELY BEFORE PLACING OF THE CONCRETE.

SLAB

- WHEN THE SLAB IS SUPPORTED ON FOUR SIDES AND LENGTH WIDTH RATIO IS LESS THAN 2, THE SLAB HAS TO BE DESIGNED AS TWO WAY SLAB.
- CARE SHOULD BE TAKEN TO PROVIDE ADEQUATE COVER AND EFFECTIVE DEPTH FOR REINFORCEMENT AT SUPPORT.
- THE CRANK BAR SHOULD NOT BE DISPLACED.Provide enough supports
- MOVEMENT OF WORKING PEOPLE ON REINFORCEMENT SHOULD BE AVOIDED.

SLAB(contd…)

- BENCH SHOULD BE PLACED FOR THE MOVEMENT OF LABOURERS.
- SLOPE OF 1 IN 60 FOR ROOF SLAB TO FACILITATE DRAINAGE.

LINTEL, SUNSHADE

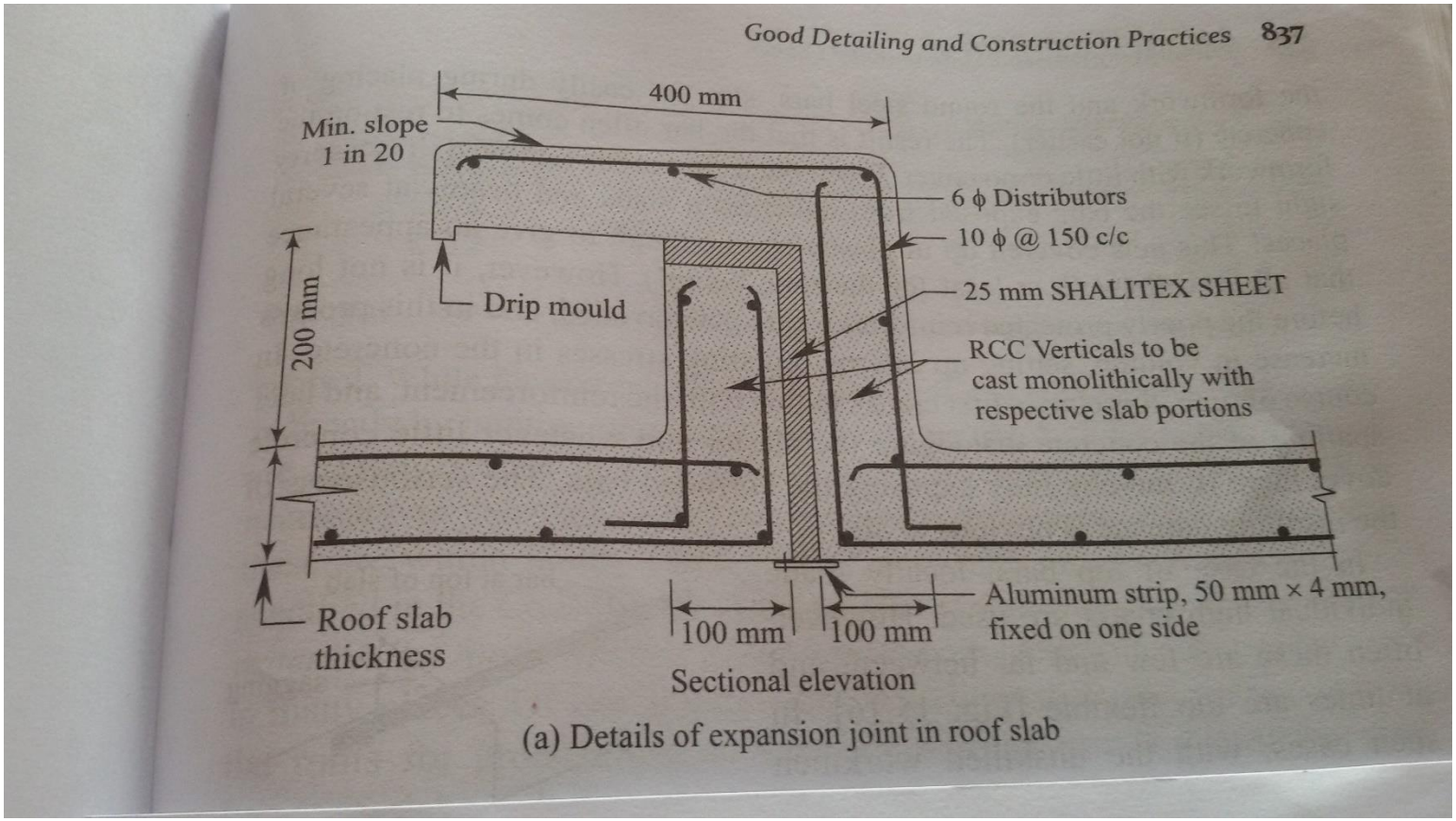
- SIZE OF LINTEL AND REINFORCEMENT MAY BE PROVIDED ACCORDING TO THE SIZE OF OPENING.

- THE DEPTH OF LINTEL WHERE THERE IS SUNSHADE SHOULD BE 5CM MORE THAN THE THICKNESS OF SUNSHADE.
- CHAIRS MUST BE PLACED AT INTERVALS TO OBTAIN THE EFFECTIVE DEPTH.
- BETTER TO PROVIDE THE SUNSHADE REINFORCEMENT AS A SEPARATE NET.
- SUFFICIENT NUMBER OF DOWN WATER PIPE WITH SUITABLE DIAMETER HAS TO BE PROVIDED.

CONSTRUCTION JOINTS IN CONCRETE

1. COLUMN - FEW Cm BELOW THE JUNCTION OF BEAM, ANCHORAGE LENGTH FOR END COLUMNS.
2. BEAM AND SLAB - AT THE POINTS OF MINIMUM SHEAR. THUS FOR THE BEAMS THE JOINTS SHOULD BE AT THE CENTRE OF SPAN OR WITHIN MIDDLE ONE THIRD.

Expansion joint in Slab



Formwork

- Formwork is an important structural system during course of concrete construction
- Although it is a temperory supporting system, it shouldnot be neglected
- The design, erection and supervision are not given due importance by field engineers and supervisors
- We often leave to carpenters at site to decide size of members of formwork,their spacing and quality
- No drawings or sketches are prepared
- No detailed inspection of formwork is carried out
- So formwork failures are common

POINTS TO REMEMBER

- Formwork should be **erected in such a way that it can be dismantled easily** without causing damage to the concrete.
- Shuttering coming in contact with concrete **should not permit leakage of cement grout.**
- Where centering posts rest on soft ground, the load should get distributed by means of thick planks or otherwise, as required.
- Centering posts should be **truly vertical** and should not be placed at an angle.
- **Levels of the formwork should** be checked and they should be as per the drawings. **No gaps** should be there in the formwork before concreting.

POINTS TO REMEMBER

- Centering should be designed and arranged so that **the sequence of removal is**: sides of columns followed by the sides of beams, boarding under the floor slabs and finally the soffits of beams.

- **Joints of formwork** should be made and maintained tight and to prevent squeezing out of grout or sucking in of air during vibration.

- **Absence of this precaution may cause** honeycombing on the surface of concrete, impairing the appearance and sometimes weakening the structure.

- Normally **gaps larger than 1.5 mm** between the boards should not be permitted. Number of **joints should be made as few as possible** by making shutter sections large.

POINTS TO REMEMBER

- Any **fan clamps or hooks** should be provided after the shuttering is completed.
- Suitable wooden plugs may be placed in the centering for electric fittings.
- Similarly, clamps for hanging ceiling fans or other purposes should also be fixed in their correct positions.
- In any event the **top of any conduit should be at least 18mm below the finished surface in order to prevent cracking**.
- To avoid sticking of concrete, **mould releasing oil** should be applied on the formwork.

Reasons for failure

- Inadequate size and spacing of props
- Use of wooden or bamboo props of inadequate strength
- Providing inclined or bent up props to support the formwork
- Props not supported on firm ground
- Lack of lateral bracing of props leads to its buckling
- Inadequate size and improper fixing of horizontal members which transfer loads to the props
- Concentration of load due to heaping of concrete or concentration of equipment and manpower
- Premature stripping of forms

POINTS TO REMEMBER

- Formwork should be left in place until the concrete has hardened enough to hold its own weight and any other weight it may be carrying.

- Where the temperature is above 20ºC and ordinary cement has been used for concreting, **formwork may be removed** after the periods given below.

Columns, vertical sides of beams and slabs	***1-2 Days***
Slabs of spans less than 3.6 meters	*08 Days*
Slabs of spans more than 3.6 meters	*14 Days*
Beams up to 6 meters span	*14 Days*
Beams more than 6 meters span	*21 Days*

Reinforcement(contd..)

- Mini. Distance between two parallel bars shall usually be not less than the greatest of:-
- 1.diameter of bar if diameters are equal
- 2.The dia. Of larger bar
- 3.5mm more than the nominal maxi. Size of coarse aggregate

Reinforcement(contd…)

- When there are two or more rows of bars,the bars shall be in line and the mini. Vertical distance between the bars shall be 15mm,2/3 the nominal size of aggregate or maxi.size of bar,which ever is greater.

Reinforcement

- Development length
- Ld=dia.xstress in bar at the section/(4xdesign bond stress)

Effect Of Shear Force

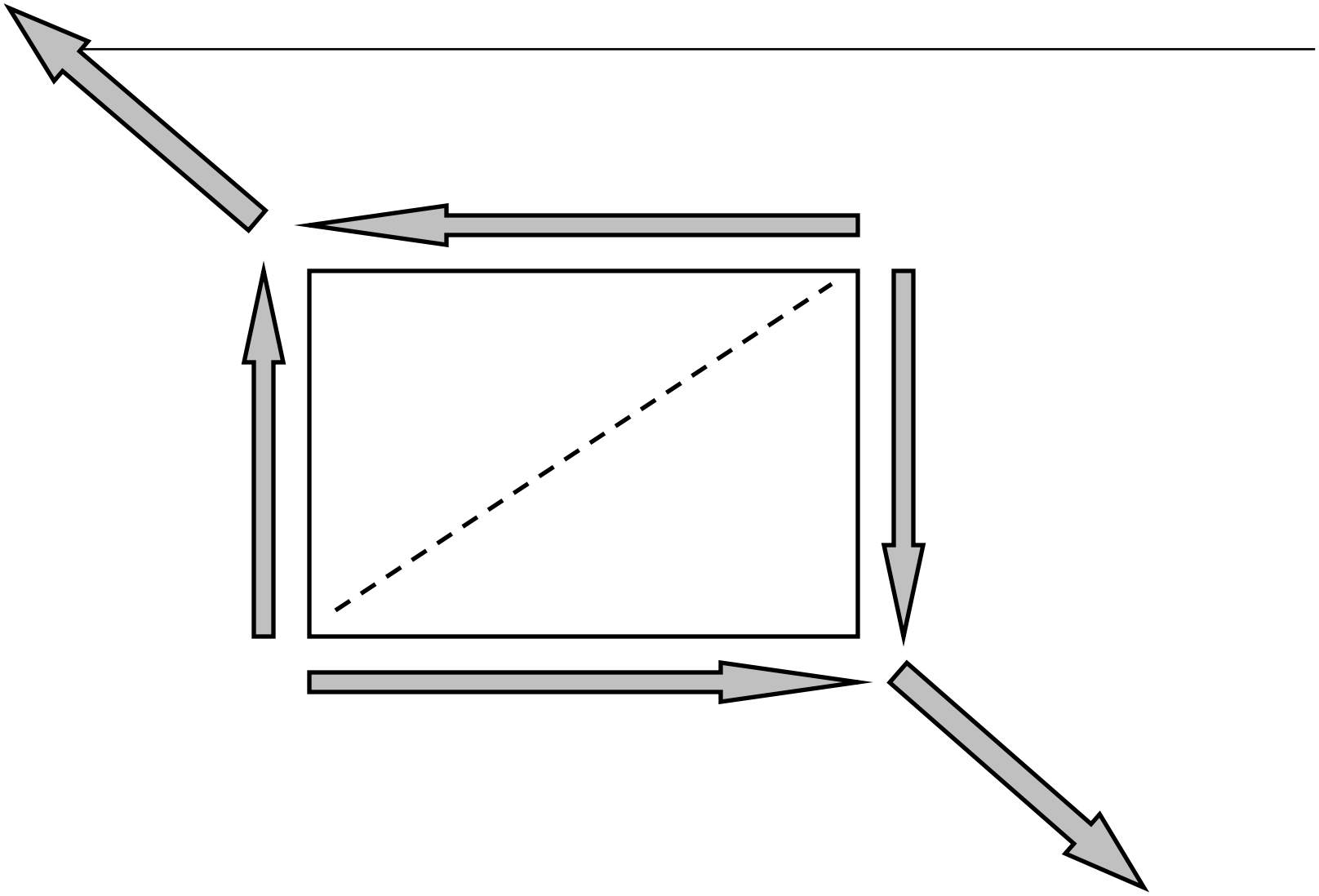


Table 5.1 Clear cover requirements for in-situ concrete (Ref. IS 456 : Cl. 25.4)

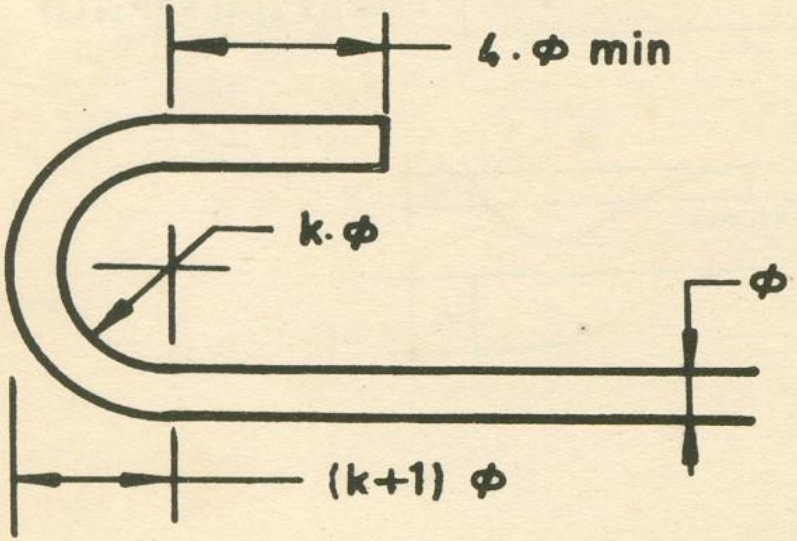
Location of reinforcement	Normal cover not less than	Additional cover in aggressive environment
Main bars in beams	25 mm or ϕ	additional 15 to 50 mm (but total clear cover not to exceed 75 mm)
Main bars in slabs	15 mm or ϕ	
Ends of main bars	25 mm or 2ϕ	
Stirrups in beams	15 mm or ϕ	
Main bars in columns		
(a) $\phi \leq 12$ mm	25 mm or ϕ	
(b) $\phi > 12$ mm	40 mm or ϕ	

Table 8.4 Development length for single bars

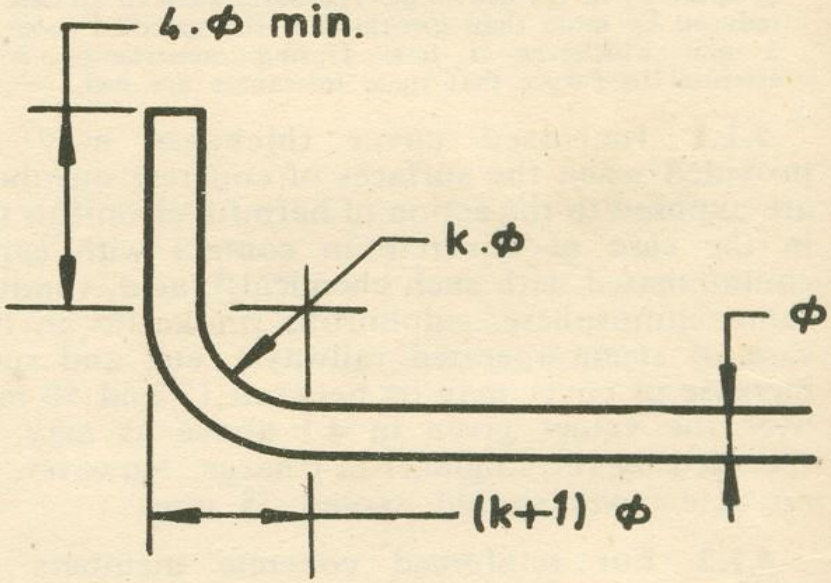
σ_y	Tension bars		Compression bars	
N/mm²	M15	M20	M15	M20
250	55 ϕ	46 ϕ	44 ϕ	37 ϕ
415	56 ϕ	47 ϕ	45 ϕ	38 ϕ
500	69 ϕ	58 ϕ	54 ϕ	46 ϕ

TABLE 4.1 ANCHORAGE VALUE OF HOOKS AND BENDS

Bar Diameter, mm	6	8	10	12	16	18	20	22	25	28	32	36
Anchorage Value of Hook, cm	9.6	12.8	16.0	19.2	25.6	28.8	32.0	35.2	40.0	44.8	51.2	57.6
Anchorage Value of 90° Bend, cm	4.8	6.2	8.0	9.6	12.8	14.4	16.0	17.6	20.0	22.4	25.6	28.8



STANDARD HOOK



STANDARD 90° BEND

STANDARD HOOK AND BEND

Type of Steel	*Minimum Value of k*
Mild steel	2
Cold-worked steel	4

Note 1 — Table is applicable to all grades of reinforcement bars.

Note 2 — Hooks and bends shall conform to the details given above.

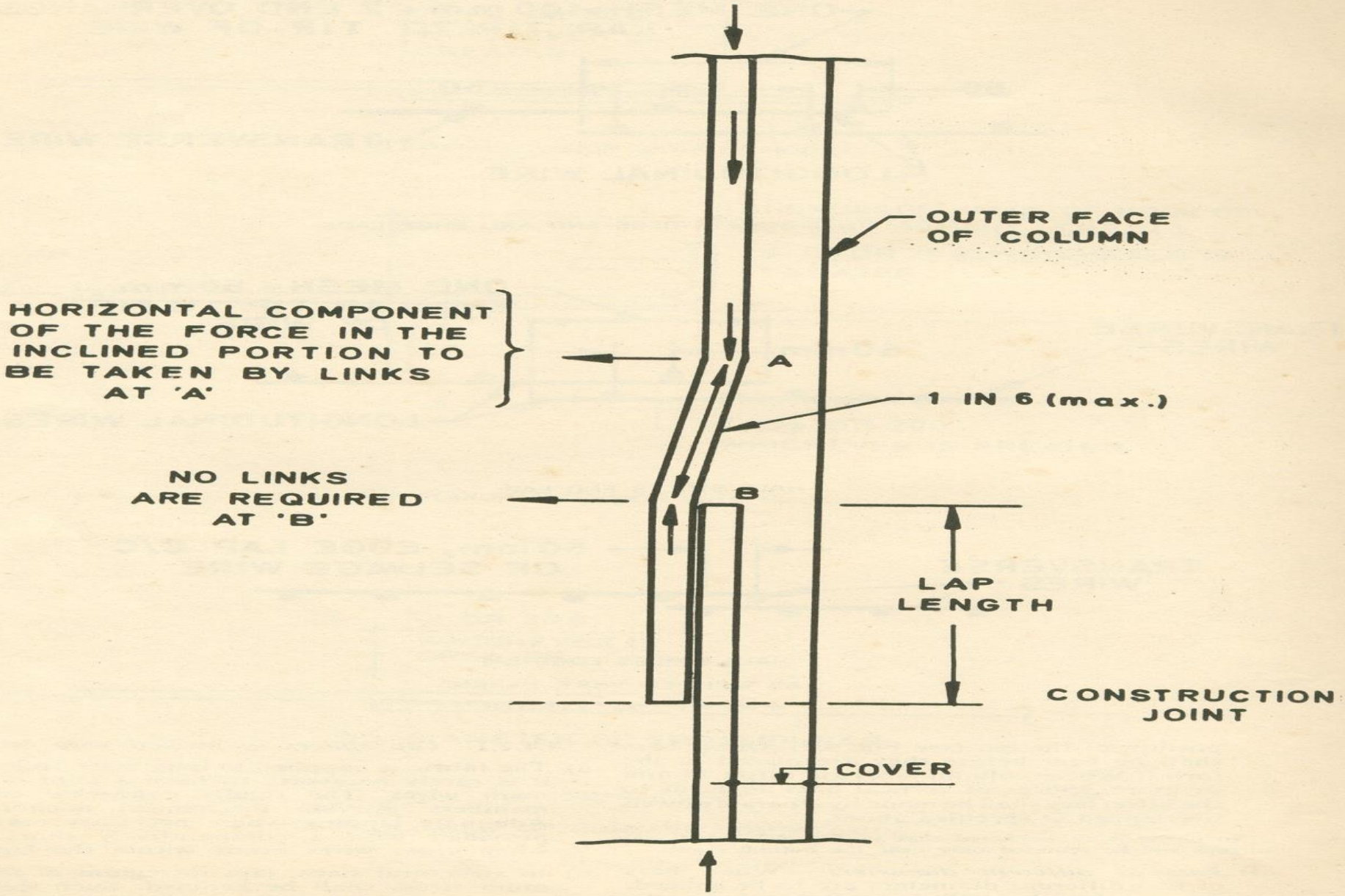
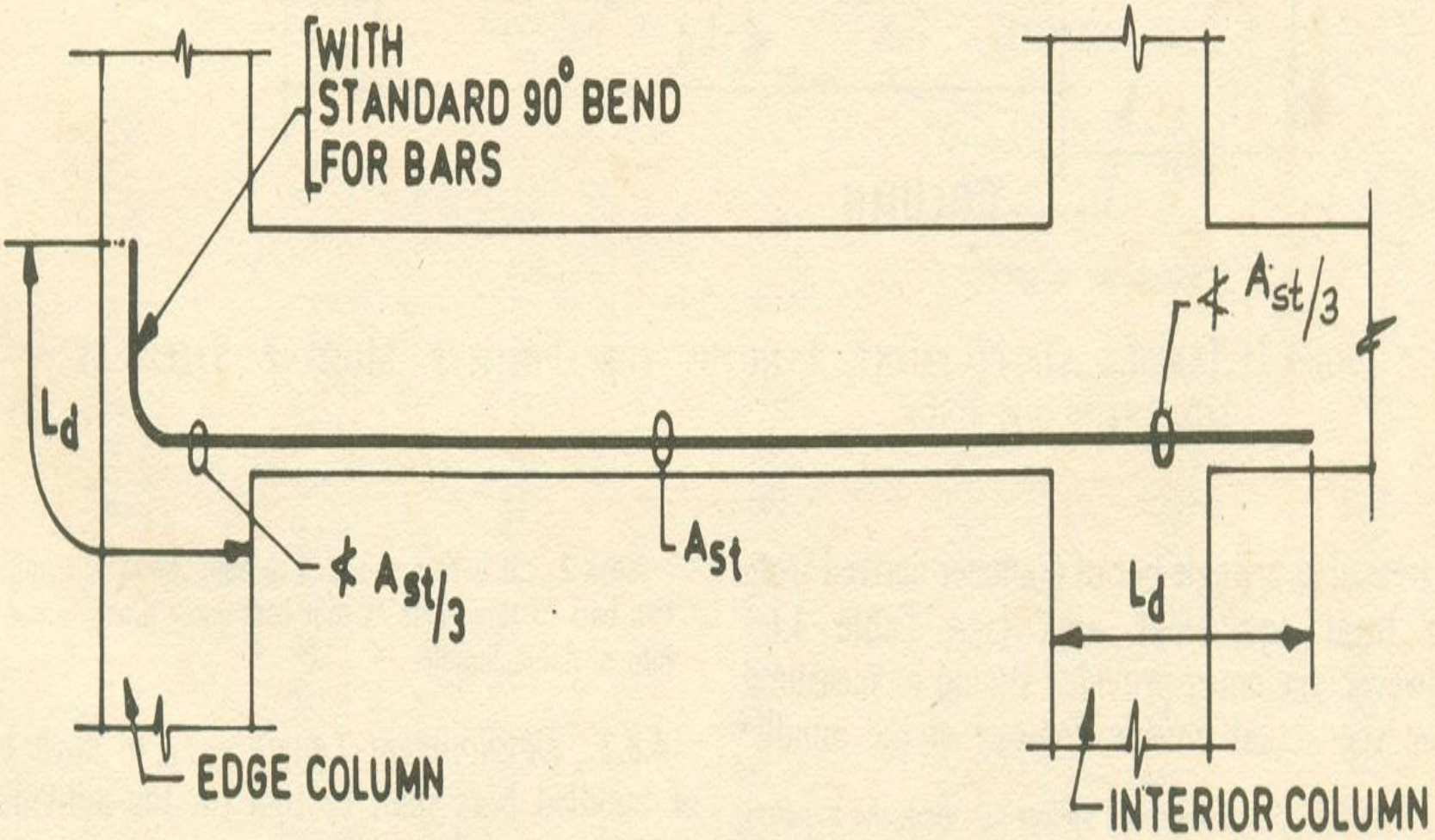
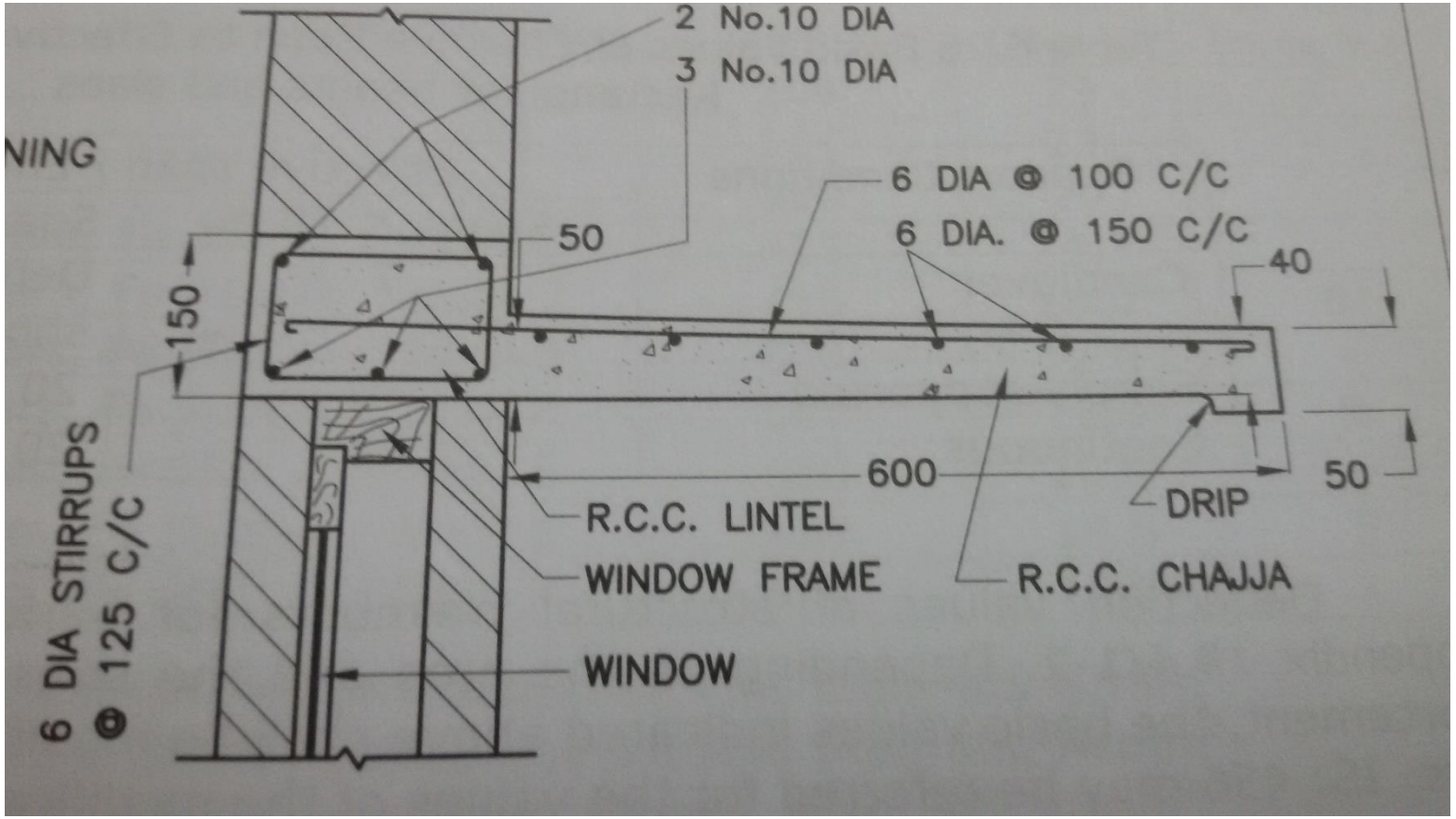


FIG. 4.7 SPLICE WITH OFFSET CRANKED BAR IN A COLUMN



L_d is development length based on fully stressed bars.

FIG. 4.19 TENSILE ANCHORAGE OF POSITIVE MOMENT STEEL IN BEAMS (WHEN BEAMS ARE PART OF A LATERAL LOAD RESISTING SYSTEM)


2 No.10 DIA
3 No.10 DIA
NING
6 DIA @ 100 C/C
6 DIA. @ 150 C/C
50
40
150
600
50
R.C.C. LINTEL
DRIP
WINDOW FRAME
R.C.C. CHAJJA
WINDOW
6 DIA STIRRUPS
@ 125 C/C

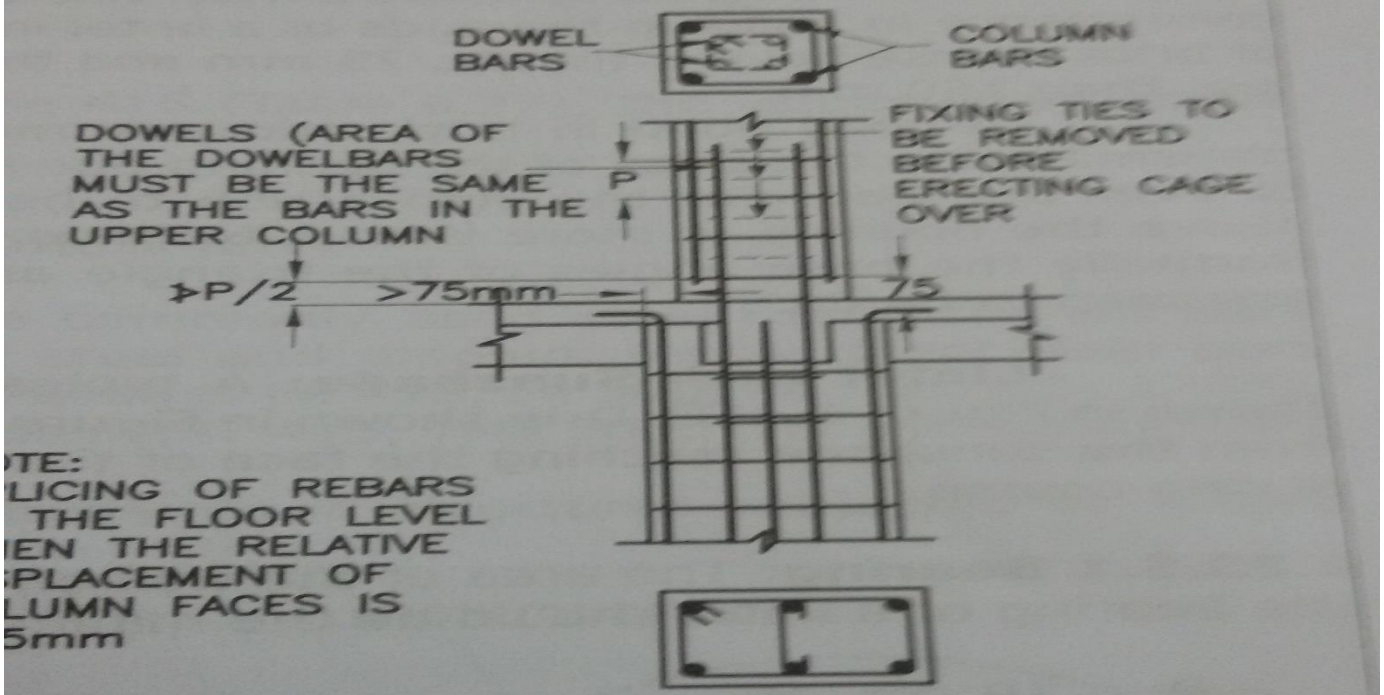
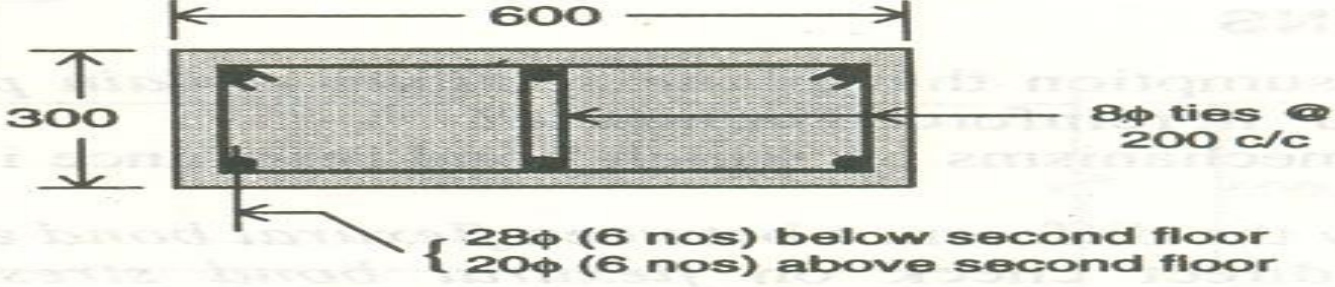


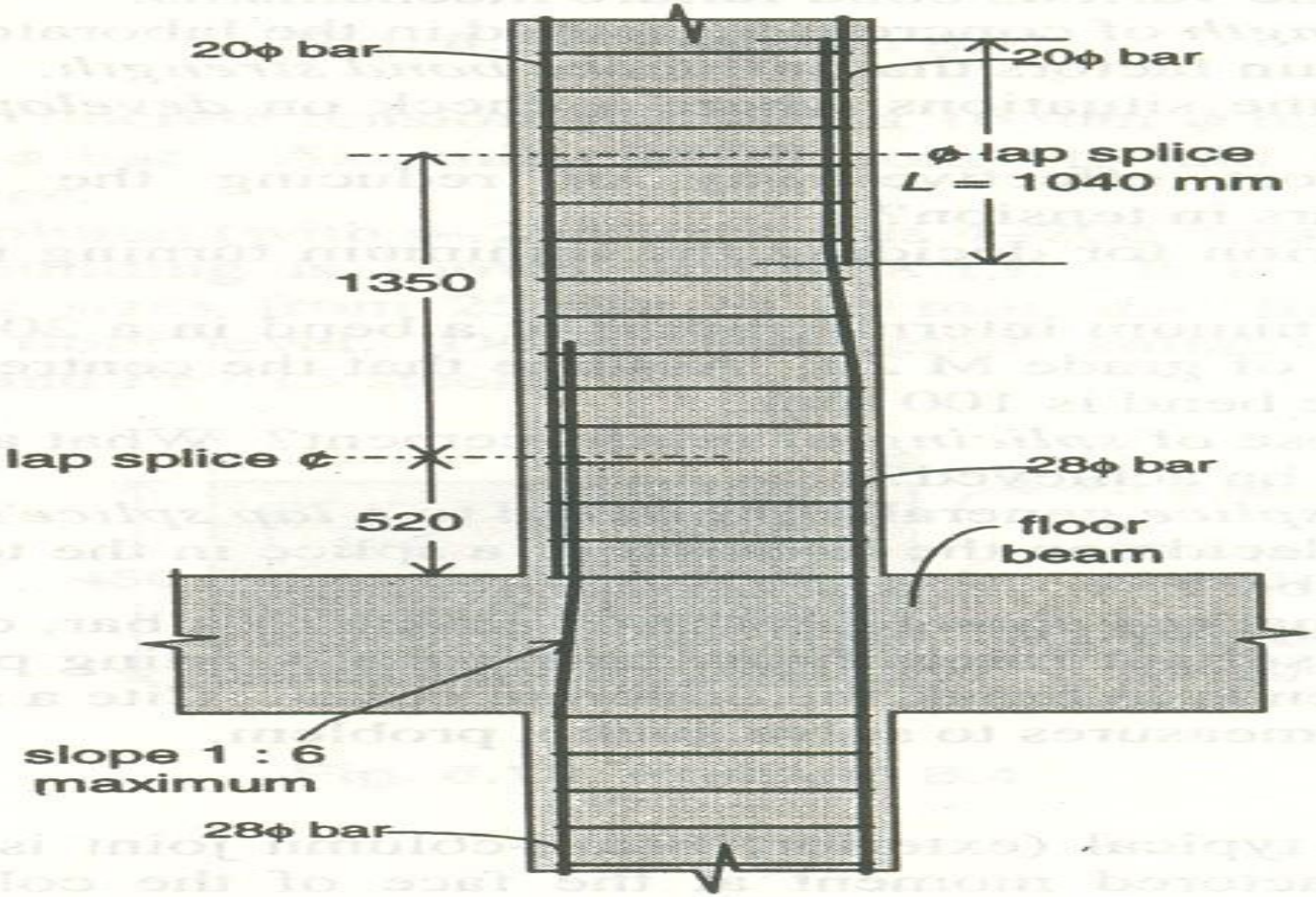
FIGURE 6.40 REBAR SPLICE DETAILS AT COLUMNS THAT ARE OFFSET

walls for doors, windows, cupboards, etc
a lintel or arch (5.17). Thus both lintel an

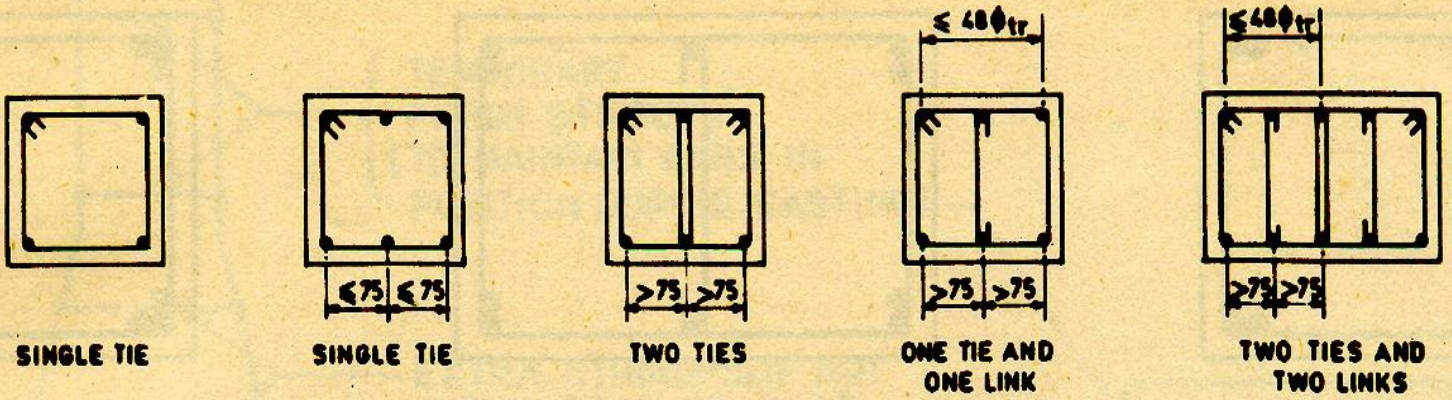
Reinforcement-detailing

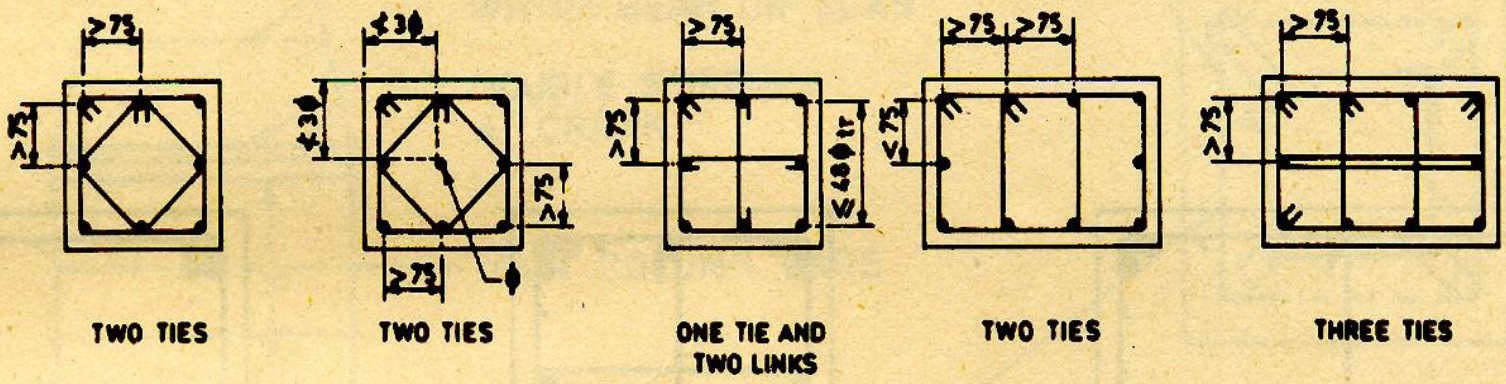


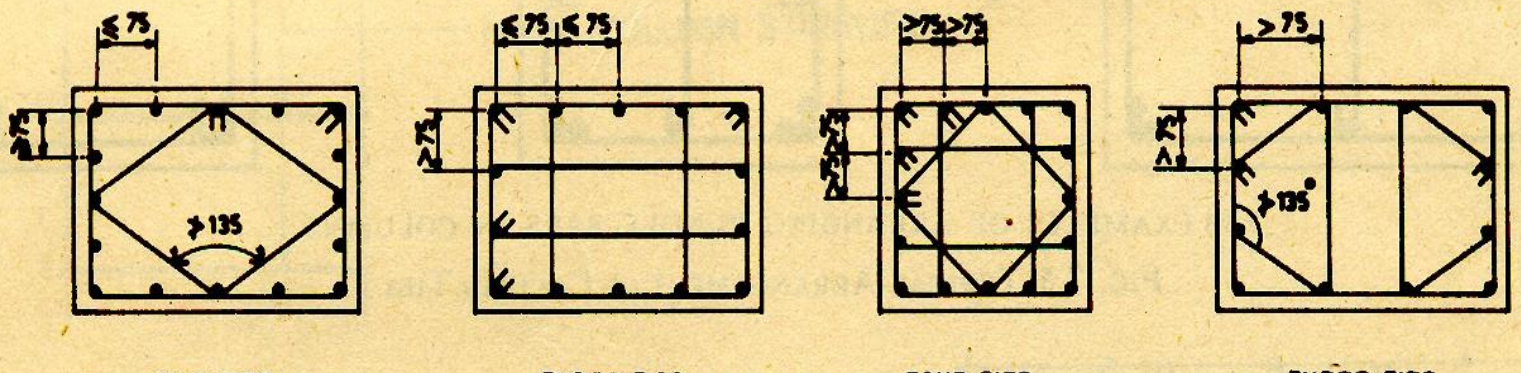
(a) plan of column

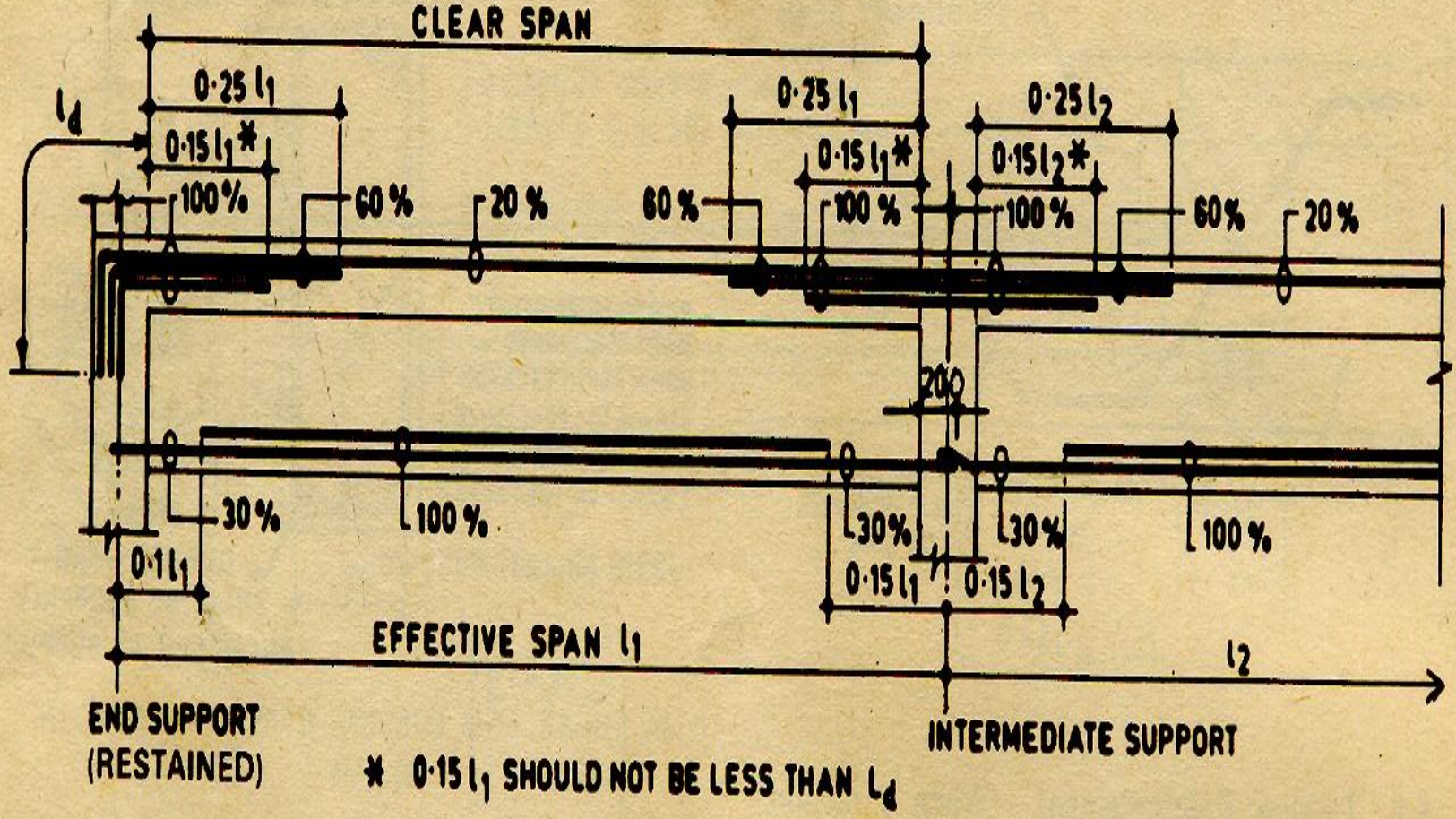


(b) typical lap slice detail
(only two bars shown here)


≤ 48 ϕ_{tr}
≤75 ≤75
>75 >75
SINGLE TIE
SINGLE TIE
TWO TIES
ONE TIE AND ONE LINK
TWO TIES AND TWO LINKS

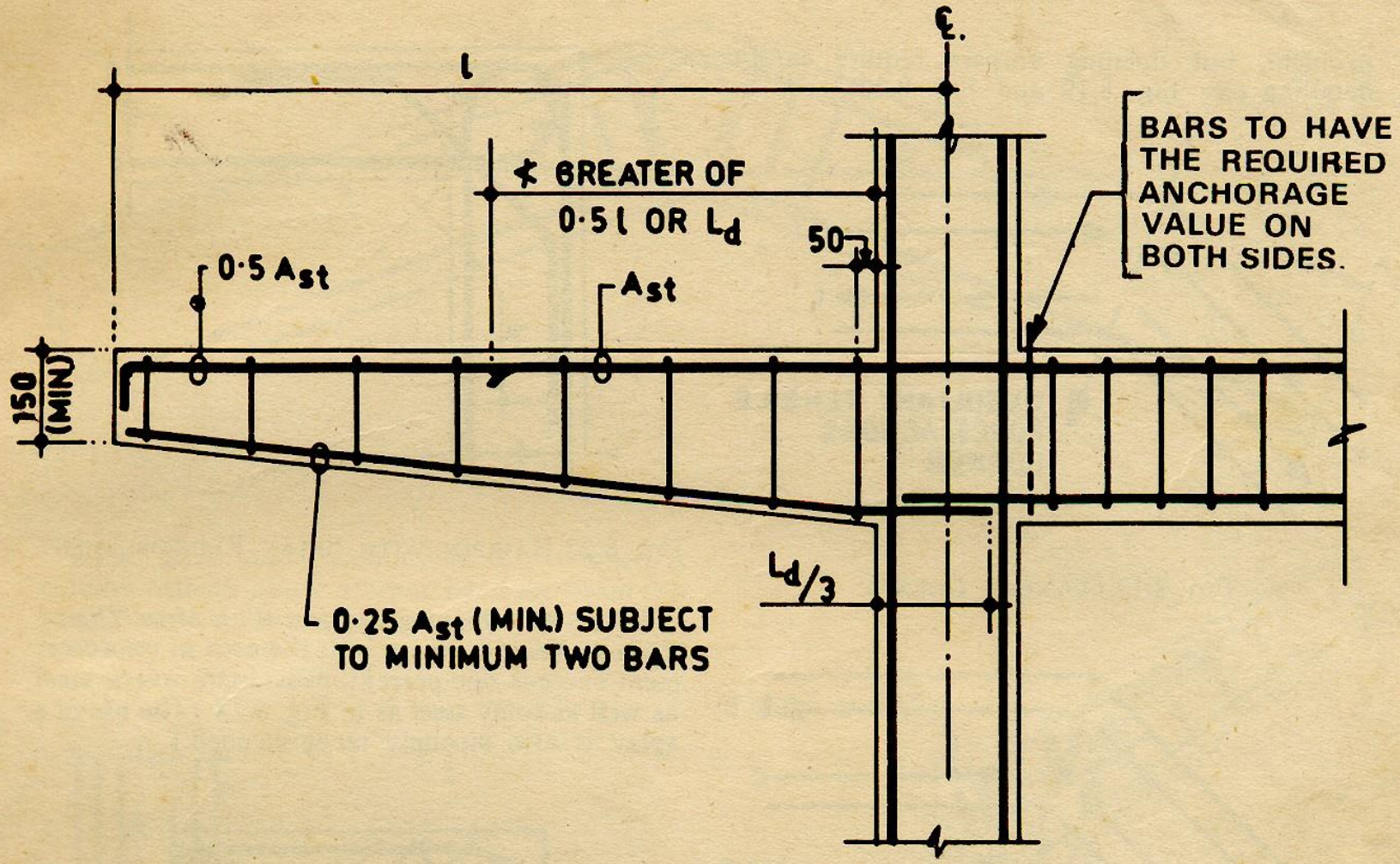

≥75
≤3ϕ
≤75
≤ 48 ϕ_{tr}
TWO TIES
TWO TIES
ONE TIE AND TWO LINKS
TWO TIES
THREE TIES


≤75
≤75 ≤75
>75 >75
≥135°
TWO TIES
THREE TIES
FOUR TIES
THREE TIES



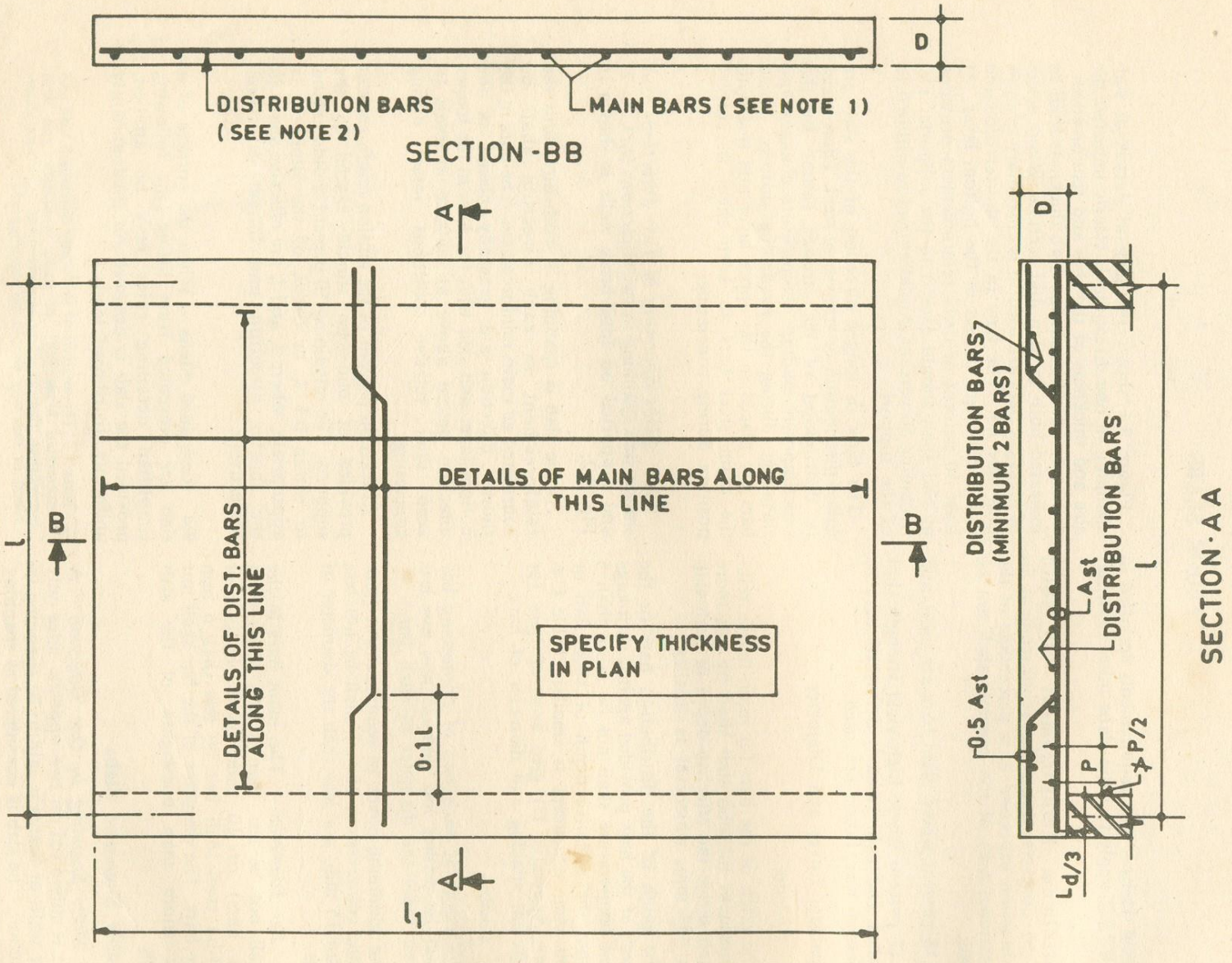
NOTE — Applicable to continuous beams with approximately equal spans (not differing more than 15 percent) and subjected to predominantly U.D.L., and designed without compression steel.

FIG. 8.15 SIMPLIFIED CURTAILMENT RULES FOR CONTINUOUS BEAMS



8.17B CANTILEVER BEAM PROJECTING FROM A BEAM OVER A COLUMN

FIG. 8.17 SIMPLIFIED CURTAILMENT RULES FOR A CANTILEVER BEAM



NOTE 1 — Diameter ≤ 8 mm for deformed bars; 10 mm for plain bars; Spacing ≥ 3d or 450 mm

NOTE 2 — Diameter ≤ 6 mm; Spacing ≥ 5d or 450 mm

FIG. 9.1 TYPICAL DETAILS OF A SLAB SPANNING IN ONE DIRECTION

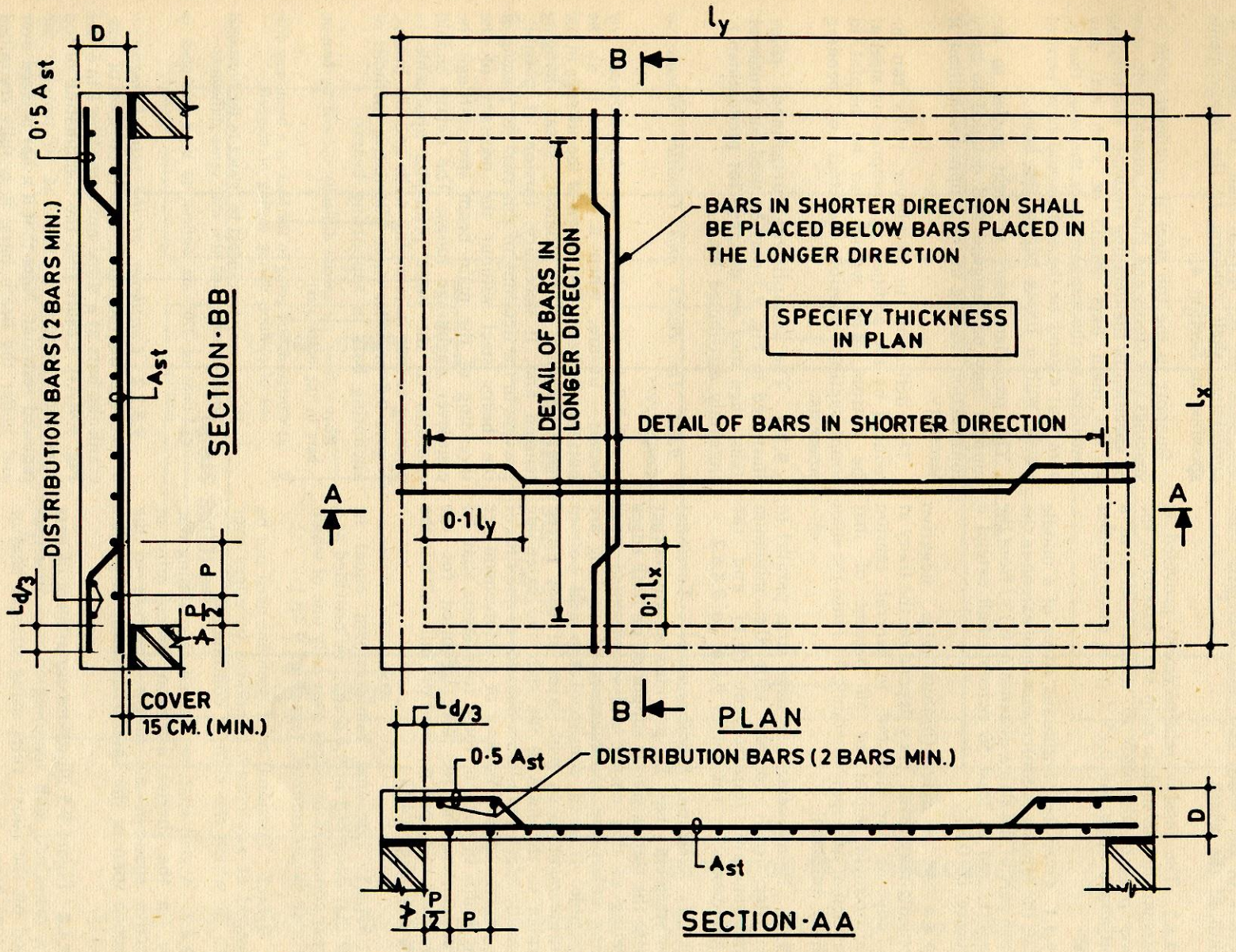
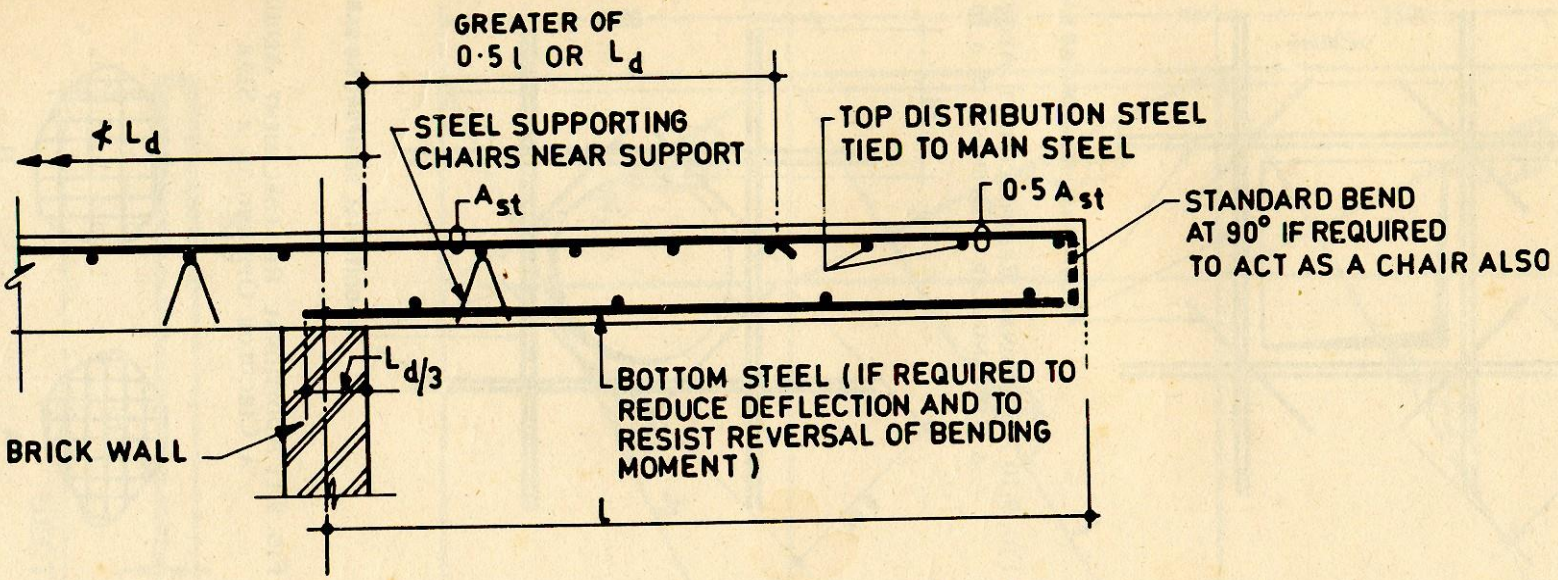
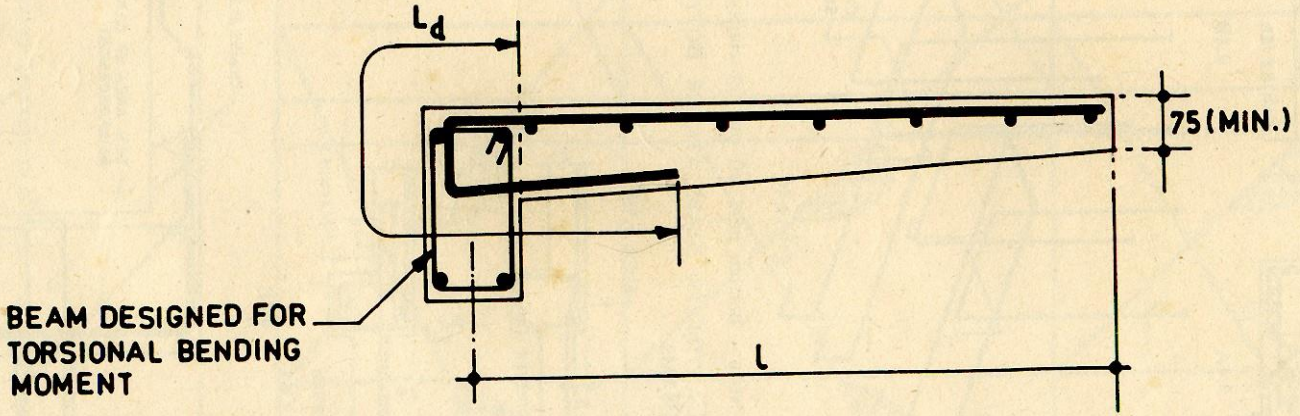


FIG. 9.2 TYPICAL DETAILS OF A SLAB SPANNING IN TWO DIRECTIONS



9.7A CANTILEVER SLAB CONTINUOUS OVER A BRICK WALL



9.7B SLAB CANTILEVERING FROM A BEAM

FIG. 9.7 CANTILEVER SLAB

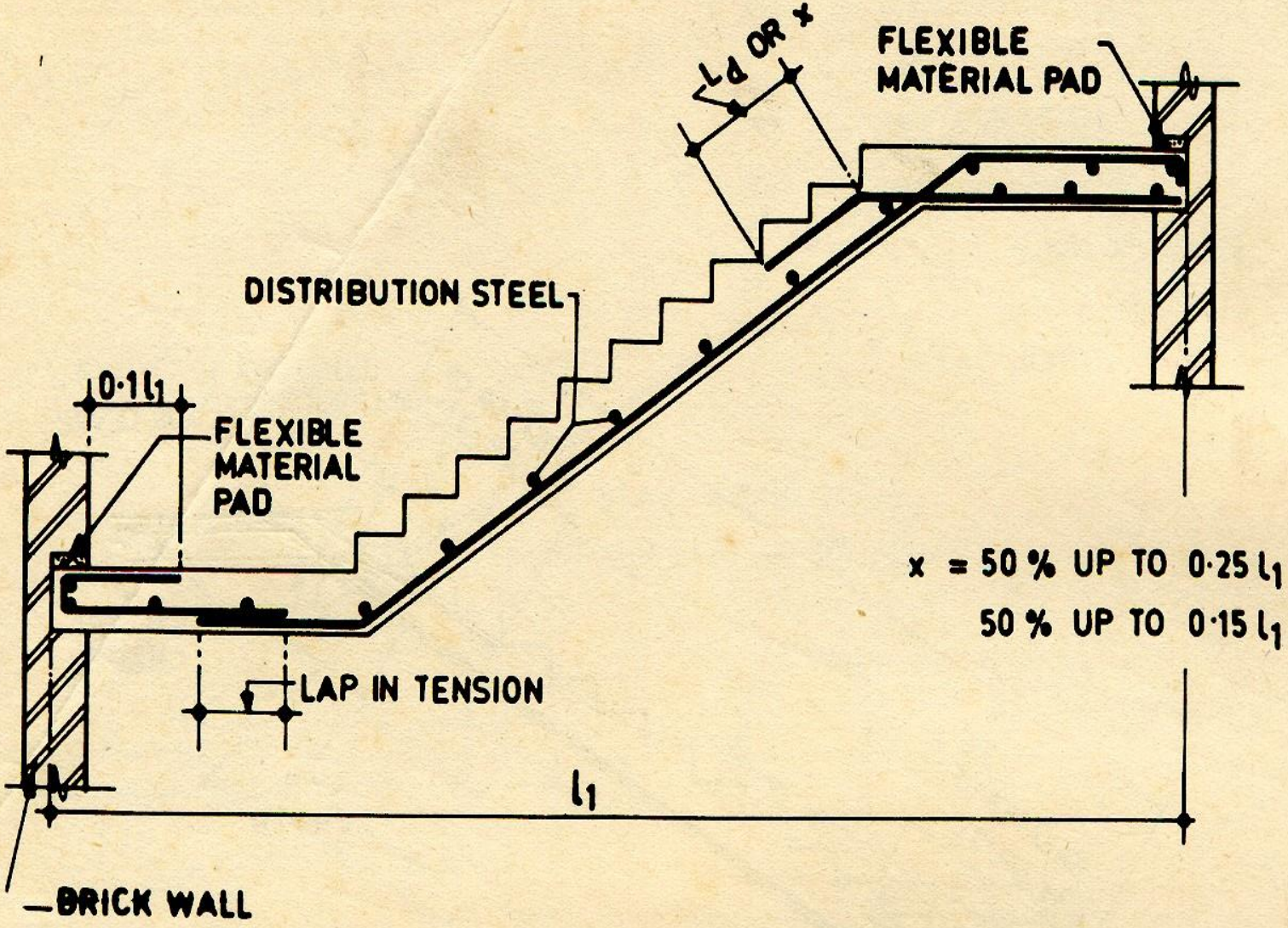
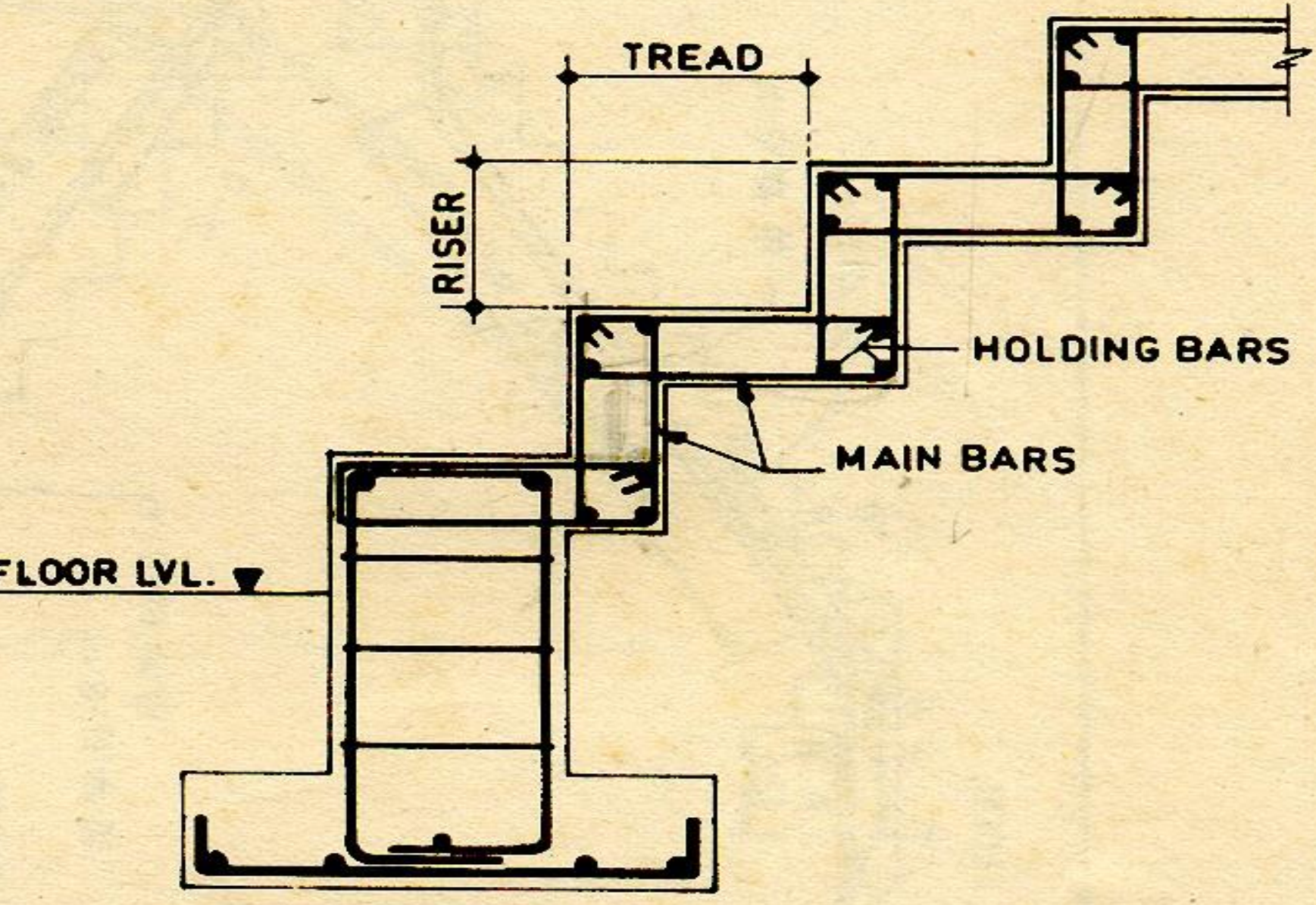
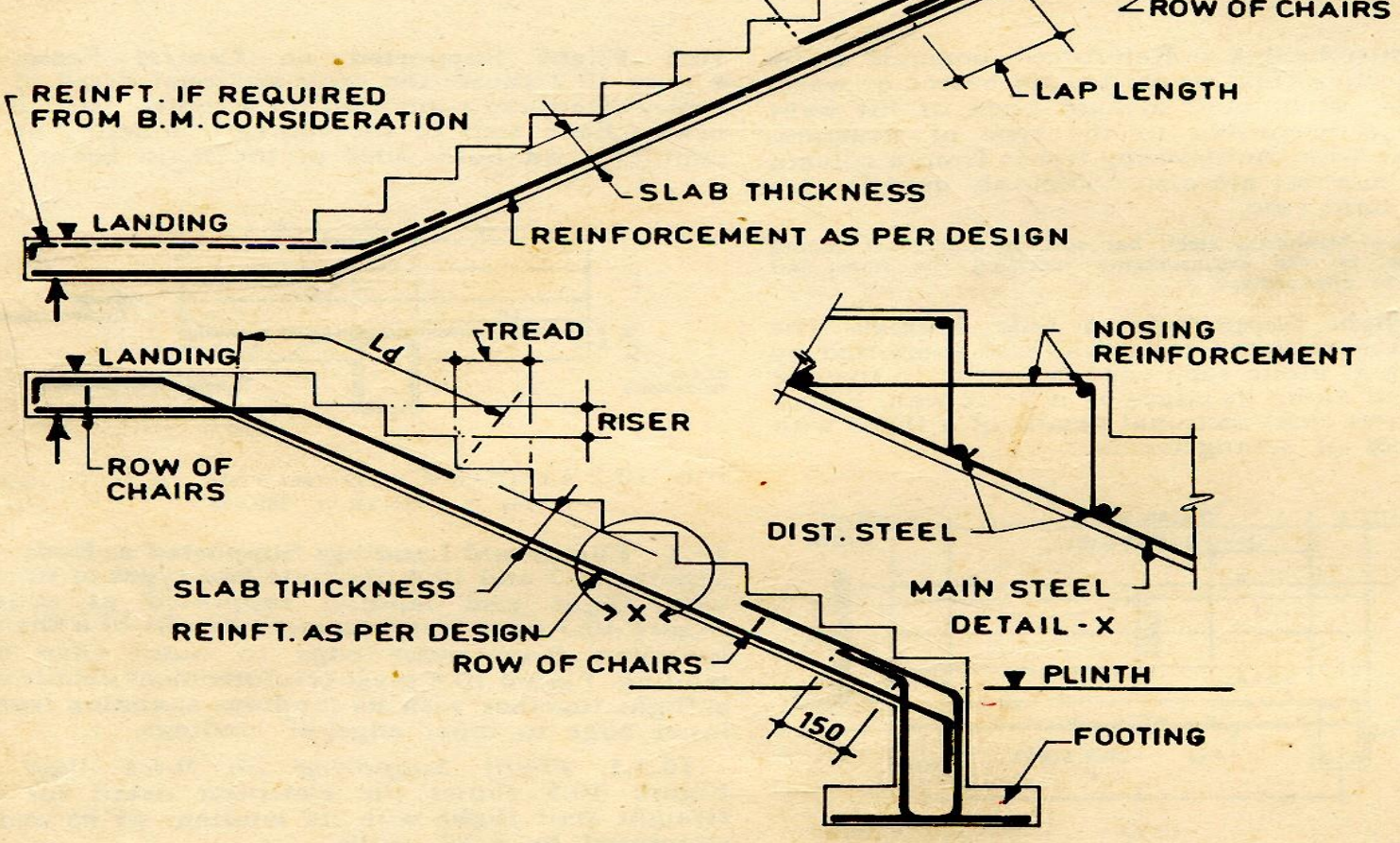
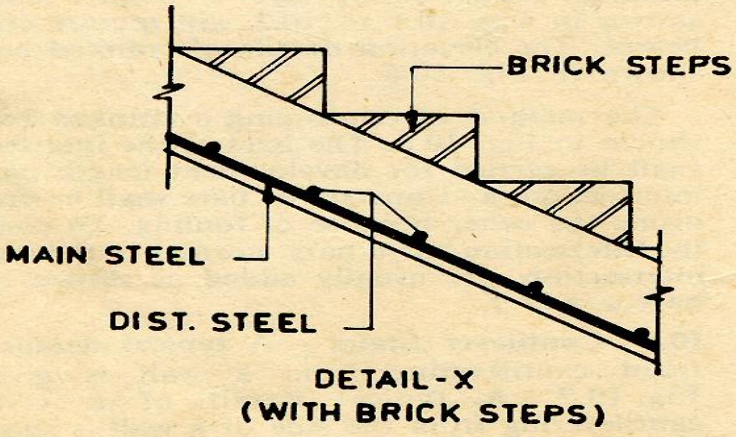


FIG. 10.5 CROSS-SECTIONAL DETAILS OF A SINGLE SPAN STRAIGHT FLIGHT SUPPORTED ON BRICK WALLS


TREAD
RISER
HOLDING BARS
MAIN BARS
FLOOR LVL.


ROW OF CHAIRS
LAP LENGTH
REINFT. IF REQUIRED
FROM B.M. CONSIDERATION
SLAB THICKNESS
LANDING
REINFORCEMENT AS PER DESIGN
LANDING
Ld
TREAD
RISER
ROW OF
CHAIRS
NOSING
REINFORCEMENT
DIST. STEEL
MAIN STEEL
DETAIL - X
SLAB THICKNESS
REINFT. AS PER DESIGN
X
ROW OF CHAIRS
PLINTH
150
FOOTING


BRICK STEPS
MAIN STEEL
DIST. STEEL
DETAIL - X
(WITH BRICK STEPS)

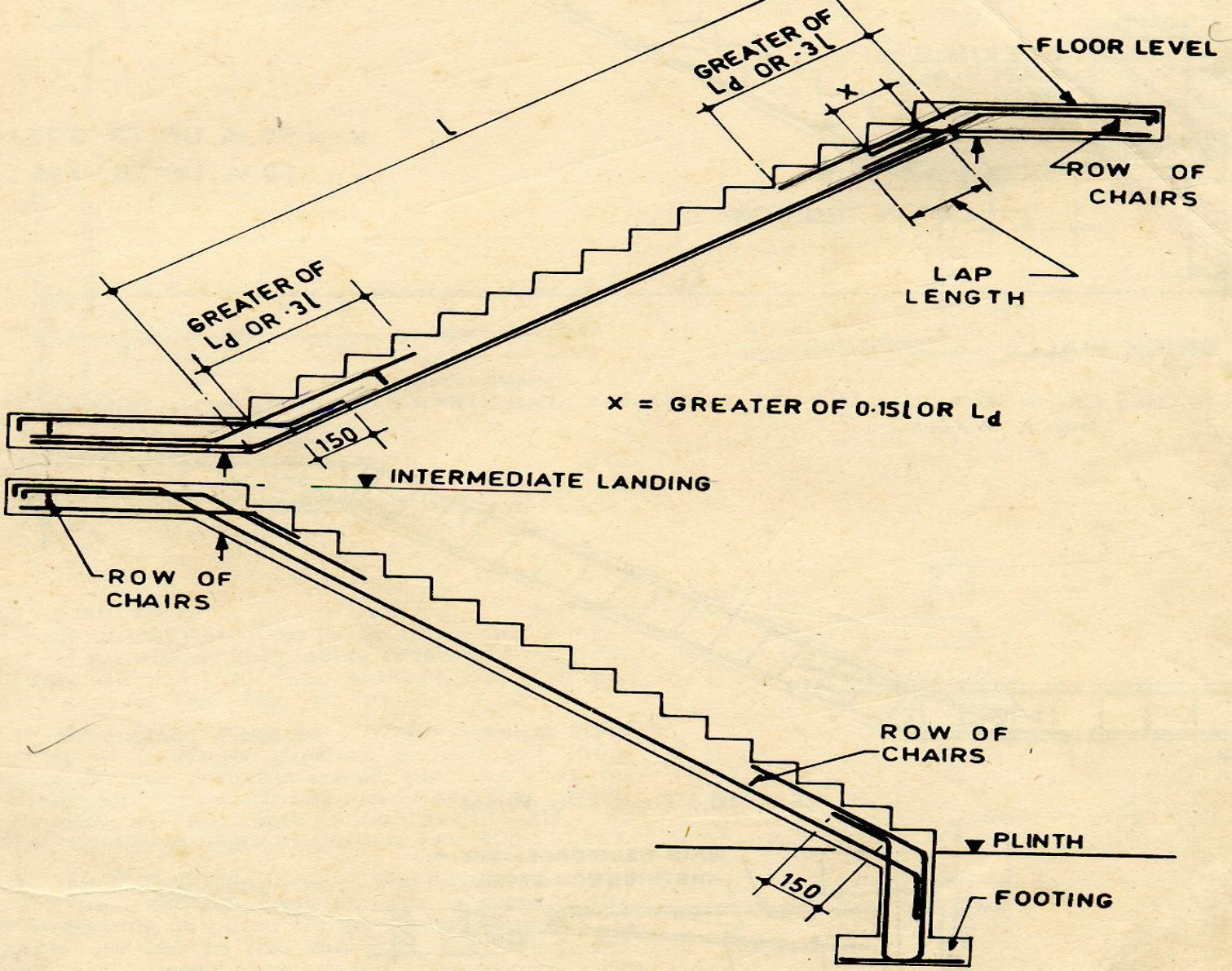


FIG. 10.4 STAIRS SUPPORTED AT ENDS OF FLIGHTS—SHOWING MAIN REINFORCEMENT

Brick work in framed structure

- As far as possible frame work should be completed before starting work of panel walls for cladding and partitioning.
- Work of construction of panel walls and partition should be deferred as much as possible and should proceed from **top to down ward**.

Stair room

- Provide concrete kerb at the bottom of the outer wall,monolithically along with the roof slab casting
- The door to the roof from stair room shall open outwards.
- Enough sunshade for the door
- Plastering of the outer wall to done carefully.

PLASTERING

- SHOULD BE FLOATED HARD AND TROWELLED SMOOTH.
- THE JOINTS TO BE RAKED AND SURFACE CLEANED BEFORE STRATING PLASTERING..
- THE PLASTERED SURFACE MUST BE IN LINE AND LEVEL AND CORNERS SHOULD BE VERTICAL.
- BEEDING, WATER CUTTING, MUST BE PROVIDED FOR SUNSHADE AND ROOF PROJECTION.
- THE JOINT BETWEEN FRAME AND WALLS TO PROPERLY TREATED.
- ATMOST CARE WHILE PLASTERING SUNSHADE TOP,&ROOF TOP.
- PROJECTING CONCRETE(lintel),MASONRY TO BE CLEARED BEFORE PLASTERING STARTS.

FLOORING

- THE BASE OF THE FLOOR SHOULD BE LEVELLED AND COMPACTED.
- CC 1:4:8, 75MM /100MM CONCRETE IS TO BE DONE.
- PROPER COMPACTION
- FOR LARGE AREA THREAD LINING
- THE THICKNESS OF MORTAR UNDER THE CERAMIC TILES SHALL NOT BE MORE THAN 20MM.

Flooring-granolithic concrete

- Suitable heavy duty floors
- Consists of rich concrete (1:1:2)wearing coat over base concrete
- Thickness varies from 10 to 40 mm
- Laid in panels (to control shrinkage cracks) formed with strips of glass, aluminium etc.
- Base concrete to cleaned and wetted for hours

Granolithic flooring(contd….)

- Neat cement slurry applied over base concrete after cleaning
- Topping then laid, well tamped and levelled
- Curing for atleast 10 days

WATER SUPPLY WORKS

- RCC WATER TANK OR PVC WATER TANK IS TO BE PROVIDED
- THE WATER TANK MAY BE SUPPORTED ON COLUMNS OR WALLS
- FOR RCC WATER TANK, A SEPARATE FLOOR SLAB MAY BE CASTED 30CM ABOVE ROOF
- PROVISION FOR CLEANING PIPE, OVERFLOW PIPE
- SIZE OF PIPE MAY BE DESIGNED AS PER REQUIRED FLOW
- FULL WAY WHEEL VALVE HAS TO BE PROVIDED
- SEPARATE TAP FOR TOILET AND BATH - SPACED FROM WALL
- PROVISION FOR ROOF – CLEANING
- PIPES TO FIXED SO THAT IT IS NOT IN CONTACT WITH WALLS USING SUITABLE CLAMPS.
- CARE IN FIXING OF DOWNWATER PIPE ON ROOF TOP

SANITARY ARRANGEMENTS

- THE BUILDING CODE DEFINES THE REQUIREMENT OF WATER CLOSET, URINALS, WASHBASINS FOR OFFICE BUILDING, HOSPITALS, SCHOOLS AND THEATRES
- SUNKEN FLOORS TO BE CAREFULLY CONSTRUCTED.
- SLOPE SHOULD BE GIVEN FOR FLOOR OF TOILET, SANITARY PIPES.
- THE SELF CLEANSING VELOCITY OF FLOW IN SEWER PIPES IS 0.75M/sec.
- MANHOLE SHOULD BE PROVIDED AT NECESSARY POINT
- SIZE OF SEPTIC TANK IS DESIGNED BASED ON THE NUMBER OF USERS
- VENT PIPE SHOULD BE RAISED TO TOP OF BUILDING
- LENGTH OF TANK 3 TO 4 TIMES THE WIDTH

Sunken Slab

- Care while concreting
- Slope for the floor
- Provide drainage pipe
- Plastering with water proofing compound and cure
- Bitumen coating@1.5kg/1m2
- Test the pipe line before filling
- Fill with granular material
- Flooring tile to extend full into the wall and dadoing resting over it.

Gradient of sewers

Diameter(mm)	Minimum gradient
100	1 in 57
150	1 in 100
200	1 in 145
230	1 in 175
250	1 in 195
300	1 in 250

SIZE OF SEPTIC TANK

NO. OF USERS	LENGTH	BREADTH	DEPTH – CLEANING INTERVAL -2Y
5	1.50	0.75	1.05
10	2.00	0.90	1.40
15	2.00	0.90	2.00
20	2.30	1.10	1.80
50	4.00	1.40	2.00
100	8.00	2.60	1.05
150	10.60	2.70	1.15
200	12.40	3.10	1.15

Septic Tank

- Anaerobic treatment process
- Microorganisms work on digestion of organic solids
- Sedimentation cum digestion tank
- Effluent contains dissolved and suspended organic solids and unsafe for disposal in open drain/water body

Septic tank(contd…)

- Tank designed for to provide a detention period of 24 to 48 hours.
- Should of water and air tight
- Free board not less than 30cm
- Tee for inlet and outlet pipes.
- The invert level of outlet pipe to be 5 to7cm below the invert level of inlet pipe.

Septic tank(contd…)

- Baffle wall near inlet pipe at a distance of 1/5 the length of tank.
- Manhole for inspection and cleaning
- The tank to be commissioned by filling with water to its outlet level and seeded with digested cowdung
- To be periodically cleaned(atleast once in 2 years)

SEEPAGE PIT/DISPERSION TRENCH

- THE EFFLUENT FROM A SEPTIC TANK SHOULD BE DISPOSED
- SEEPAGE PIT MAY BE LINED WITH STONE, BRICK WITH DRY OPEN JOINTS
- PACKED WITH COURSE AGGREGATE
- COVERED WITH REMOVABLE PRECAST SLAB
- DISPERSION TRENCH 1M WIDTH, 1M DEPTH, 30M LENGTH
- TRENCHES SHOULD NOT BE PLACED CLOSER THAN 2M
- OPEN JOINTED PIPES ARE PLACED WITH DIA 100MM MINIMUM
- CRUSHED STONES ARE FILLED IN THE DISPERSION TRENCH

Causes of cracks

- Drying shrinkage
- Thermal movement
- Elastic deformation
- Creep
- Chemical reaction
- Foundation settlement
- Growth of vegetation

Moisture

- Most of the building materials (e.g. Concrete, mortar, burnt clay brick, timber,plywood etc.,) are porous in their structure in the form of inter-molecular
- space, and they expands on absorbing moisture from atmosphere and shrinks on drying. These movements are **reversible** i.e. cyclic in nature and are caused by increase or decrease in the inter-pore pressure with moisture change.

Shrinkage crack

- Cement based materials undergo irreversible movement due to drying out of moisture used in its construction
- Initial shrinkage of concrete and mortar occurs only once in the life time, i.e. at the time of manufacture/construction, when the moisture used in the process of manufacture/construction dries out.
- In concrete 1/3 shrinkage takes place in first 10 days,half within a month and remaining in about a year.
- Factors affecting-w/c ratio,aggregate,curing,type of cement……

Plastic Shrinkage

- Immediately after placing the concrete, solid particles tends to settle down by gravity action and water rises to the surface. This process – known as **bleeding**- produces a layer of water at the surface and this process continues till concrete has set. As long as the rate of evaporation is lower than the rate of bleeding, there is a continuous layer of water at the surface known as **"water sheen"**, and shrinkage does not occur. When the concrete surface looses water faster than the bleeding action bring it to the top, shrinkage of top layer takes place, and since the concrete in plastic state can't resist any tension, cracks develops on the surface

Thermal movement

All materials, more or less expand on heating and contract on cooling.

When movement is restrained internal stresses are set up, resulting in cracks due to tensile /shear stresses.

Coefficient of thermal expansion

brick-	5-7 10-6/0C
concrete	10-14 …
aluminium	25…..
steel	11-13……
granite	8-10

Very large forces are brought into play if this movement is restrained.

Thermal cracks …..

- A force of 500 kN is required to restrain the expansion of a strip of concrete 1 metre wide,0.1 mm thick, heated through 22oC.
- Cracks due to thermal expansion open and close alternatively (shrinkage and other cracks not so)
- Internal walls not affected by thermal expansion

Creep

- Some building materials such as concrete, brick when subjected to sustained loading not only undergo elastic deformation, but also exhibit a slow time dependent deformation.
- In concrete most of the creep takes place in the first month and thereafter slows down.
- The major affect of creep in concrete is the substantial increase in the deformation of structural members, which may be to the extent of **2 to 3 times** the initial elastic deformation.
- Creep strain can be reduced by deferring removal of formwork and application of external load.

Foundation movement

Unequal bearing pressure under parts of the structure.

Bearing pressure in excess of SBC

Low factor of safety in design

Local variations in the nature of soil, remained undetected and not taken care of in the designs.

Cracking due to vegetation

- Roots of trees spread horizontally and to be viewed with suspicion. Expansive action of roots growing may crack the wall.
- Growing roots cause dehydration of soil which may shrink and cause foundation settlement.
- In areas where old trees are cut off, roots had dehydrated the soil. On receiving moisture (rain), soil may swell and cause upward thrust.
- If vegetation and trees have been removed and soil is shrinkable clay, better to wait for a rainy season for the soil to undergo expansion and stabilisation.

Cracks in walls

- Avoid rich mix for masonry and delay plaster work till masonry has dried out after proper curing and has undergone initial shrinkage.
- Slip joint shall be introduced between slab and supporting wall.
- Over flat slab layer of some insulating material having good heat insulating capacity and with high reflective finish to reduce heat load on roof(lime mortar with broken porseline in western India)

Cracks (contd….)

- When RCC and brick work occurs in combination and to be plastered, then sufficient time **(atleast 1 month)** shall be allowed for RCC and brickwork to undergo initial shrinkage and creep before taking up plaster work.
- On the inside, wall plaster and ceiling plaster should be made discontinuous by a groove of about 10 mm.
- Before fixing of tiles on vertical surface background component should be allowed to under go movement due to elastic deformation, shrinkage & creep otherwise tiles are likely to crack and dislodged.

Cracks……

- Vertical cracks below openings in masonry-Due to differential stress, shear cracks develop. To avoid lintels and plinth beams should have good shear strength.
- Horizontal cracks in walls of framed structure-since walls are subjected to large compressive force due to elastic deformation, creep, drying shrinkage etc. Apparent becomes a few years after the construction. Can be minimised if the time gap between construction of frame and masonry is more.

Pace of Construction

- All items of masonry are properly cured and allowed to dry before plastering work is done, thus concealing the cracks in masonry in plaster work.
- Similarly plaster work should be cured and allowed to dry before applying finishing coat, so as to conceal the cracks in plaster under finish coat.
- In case of concrete work before taking masonry work either over it or by its side, the most of the drying shrinkage, creep and elastic deformation of concrete should be allowed to take place, so as to avoid cracks in masonry or at the junction of masonry and concrete

Extension of Building-Horizontal

- Since foundation of building undergoes some settlement as load comes on the foundation, it is necessary to ensure that new construction is not bonded with the old construction and the two parts are separated by a slip or expansion joint right from bottom to top.
- Otherwise, when the newly constructed portion undergoes settlement, an unsightly crack may occur at the junction.

Extension-vertical

- When making vertical extension to an existing building work should be proceeded at a uniform level all round so as to avoid differential load on the foundation.
- Renewal of finishing coats on old walls of old portion should be deferred for 2 or 3 months after the imposition of additional load due to new construction so that most of the likely cracking should take place before finish coat is applied thus concealing the cracks.

- The commonly used building material like masonry, concrete, mortar etc. are weak in tension and shear.
- Therefore the stresses of even small magnitude can lead to cracking.
- Internal stresses are induced on account of thermal movements, moisture change, elastic deformation, chemical reactions etc..

- All these phenomenon causes dimensional changes in the building components
- whenever this movement is restraint due to interconnectivity of various member, resistance between the different layers of the components etc., stresses are induced ,resulting in cracking

Structural Cracks : These occur due to incorrect design, faulty construction or overloading and these may endanger the safety of a building. e.g. Extensive cracking of an RCC beam.

A	B	C	D	E	F	G	H	I	J	K	L	M
1	2	3	4	5	6	7	8	9	10	11	12	13
N	O	P	Q	R	S	T	U	V	W	X	Y	Z
14	15	16	17	18	19	20	21	22	23	24	25	26

K N O W L E D G E

11+ 14 + 15+ 23+ 12 +5 + 4+ 7 + 5 = ***96***

S K I L L S

19 + 11 + 9 + 12 + 12 + 19 = ***82***

H A R D W O R K

8 + 1 + 18 + 4 + 23 + 15 + 18 + 11 = ***98***

T A L E N T

20 + 1 + 12 + 5 + 14 + 20 = ***72***

A T T I T U D E

1 + 20 + 20 + 9 + 20 + 21 + 4 + 5 = ***100***

THANK YOU