## **TECHNICAL INFORMATION**

## GENERAL

## **CONVERSION FACTOR**

		To Convert	То	Multiply by	Reciprocal
1.	Length	Inches	Centimetres	2.540	0.3937
	_	Feet	Metres	0.305	3.2808
		Yards	Metres	0.914	1.0936
		Miles	Kilometres	1.609	0.6214
		Miles	Naut-miles	0.8690	1.1508
		Naut-miles	Kilometres	1.852	0.5400
		Kole (Carpenter's)	Metres	0.720	1.3888
		Angulam (")	Centimetres	3,000	0.3333
2.	Area	Sq. inches	Sq. centimetres	6.452	0.1550
		Sq.feet	Sq. metres	0.093	10.7636
		Sq. Yards	Sq. dekametres (Ares)	0.008	119.6170
		Acres	Hectares	0.405	2.4710
		Sq. Miles	Hectares	259.000	0.3861 x 10 <sup>-2</sup>
3.	Volume	Cu. inches	centimetres (Millilitres)	16.3871	0.0610
		Cu. feet	Cu. metres (Kilolitres)	0.028	35.3147
		Cu. feet	Litres	28.316	0.0353
		Cu. feet	Gallons (Imp)	6.229	0.1605
		Acre feet	Cu. metres	1283.502	0.8107 x 10 <sup>-3</sup>
4.	Capacity	Fluid ounces (U.K)	Cu. centimetres	28.413	0.352
		Fluid ounces (U.S)	Cu. centimetres	29.574	0.0338
		Gallons (Imp)	Litres	4.546	0.220
		Gallons (Imp)	Gallons (U.S)	1.200	0.8331
		Travancore Parah	Litres	13.110	0.0763
		Do.	Cu. inches	800.000	0.00125
		Kandy (Carpenter's)	Cu. metres	0.373	2.6792
5.	Weight	Ounces	Grams	28.350	0.0353
		Pounds	Kilograms	0.454	2.2046
		Tons	Tonnes	1.016	0.9842
6.	Density	Pounds per cft	Grams per cu. cm	0.016	62.4283
	,	Do.	Kg per cu.metre	16.019	0.0624
		Pounds per gallon	Kg per litre	0.100	10.0221
7.	Linear density	Pounds per foot	Kg per metre	1.488	0.6720
8. 9.	Force Strees &	Pounds	Dynes	13825.500	72.33 x 10 <sup>-6</sup>

Pressure	Newton per sq.mm	Kg.per Sq. cm	10.97	0.0981
	Pounds per sq. inch	Do.	0.703	14.2248
	Pounds per sq.foot	Kg. per Sq.m.	4.882	0.2048
	Tons per sq. foot	Tonnes per Sq.m.	10.937	0.0914
	Head of water in feet	Pounds per Sq. in.	0.434	2.3067
	Do.	Kg per Sq. cm.	0.035	32.8093
	Inches of mercury	Do.	0.035	28.9590
	Do.	Pounds per Sq.in.	0.491	2.0360
0. Power	Horse power	Metric horse power	1.014	0.9863
	Do.	Kilowatts .	0.746	1.3410
	Foot pounds per second	Do.	$0.1356 \times 10^{2}$	737.562
1. Velocity	Feet second	Miles per hour	0.682	1.4667
,	Do.	Kilometres per hour	1.097	0.9113
	Milles per hour	Centimetres per sec.	44.704	0.0224
12. Temperature	(Fahrenheit)	(Centigrade)	(F-32) x 5/9	$(c \times 9/5) + 32$
3. Moment of				
inertia	Inch units	Centimetre units	41.623	0.0240
	Foot units	Metre units	0.009	115.8620
4. Section				
Modulus	Inch units	Centimetre units	16.387	0.0610
	Foot units	Metre units	0.283	35.3147
15. Bending				
moment	Foot pounds	Kilogram metres	0.138	7.2330
	Inch pounds	Kilogram centimetres	1.152	0.8680
6. Momentum	Pound foot per sec.	Kg. metre per sec.	0.138	7.2330
17. Illumination	Foot candle	Lux	10.764	0.0929
TABL	E OF CIRCUMFEREN	ICE AND AREAS OF	PLANE FIGU	<b>JRES</b>
Title		Area	Cicum	ference
			or Per	imeter
Rectangle		lb	2(I+b)	
Square		$a^2$	4a	
•				
Triangle	1	√S(s - a)(s - b)(s - c)	a + b +	c = 2s
Equilateral triangl	e	$= \frac{\sqrt{3a^2}}{a^2} = 0.433a^2$	3a	
sosceless right a	angled triangle	4 0.5a²	3.414a	ı
osceless right a	angled triangle	0.5a <sup>2</sup>	3.414a	l

То

Multiply by

 $2\pi$  r or  $\pi d$ 

Reciprocal

To Convert

Hexagon (regular)

Sector of circle

Circle

360

Area of Sector, Area of Triangle or approx: 2/3 maximum ht. x width Segment of Circle

Ellipse  $\pi ab$  $\pi(a+b)$  appx

Note: Area of similar figures will be proportional to the square of their corresponding sides.

## 1.3. VOLUME AND SURFACE AREAS OF SOLIDS

Title	Volume	Surface Area
Prism	Base area x height	Circumference of base x height
Cylinders	$^{\pi r^2 h} \mathfrak{A}^3$	$2\pi rh$
Sphere	$\frac{\pi r \cdot n}{4/3\pi r^3} = \frac{\pi d^3}{6}$	$4\pi r^2$
Pyramid	1/3 base area x height	1/2 perimeter x slant height
Frustum of pyramid	$\frac{h}{3}\left((A_B + A_b + \sqrt{A_B \cdot A_b}\right)$	·

## WEIGHT AREA & PERIMETER OF STEEL BARS

WEIGHT, AREA & PERIMETER OF STEEL BARS							
Dia	ROUNDS			SQUARE BARS			
Width	Wt	Area	Peri		Wt.	Area	Peri.
mm	kg.	cm <sup>2</sup>	cm		kg.	cm <sup>2</sup>	cm
5.0	0.15	0.20	1.57		0.20	0.25	2.0
5.5	0.19	0.24	1.73		0.24	0.30	2.2
6.0	0.22	0.28	1.88		0.28	0.36	2.4
7.0	0.30	0.38	2.20		0.38	0.49	2.8
8.0	0.39	0.50	2.51		0.50	0.64	3.2
9.0	0.50	0.64	2.83		0.64	0.81	3.6
10	0.62	0.79	3.14		0.78	1.00	4.0
11	0.75	0.95	3.46		0.95	1.21	4.4
12	0.89	1.13	3.77		1.13	1.44	4.8
14	1.21	1.54	4.40		1.54	1.96	5.6
16	1.58	2.01	5.03		2.01	2.56	6.4
18	2.00	2.54	5.65		2.54	3.24	7.2
20	2.47	3.14	6.28		3.14	4.00	8.0
22	2.98	3.80	6.91		3.80	4.84	8.8
25	3.85	4.91	7.85		4.91	6.25	10.0
28	4.83	6.16	8.80		6.15	7.84	11.2
32	6.31	8.04	10.05		8.04	10.24	12.8
36	7.99	10.18	11.31		10.17	12.96	14.4
40	9.86	12.57	12.57		12.56	16.0	16.0
45	12.49	15.90	14.14		15.90	20.25	18.0
50	15.41	19.64	15.71 17.59		19.62	25.00	20.0
56	19.34	24.63	17.59		24.62	31.36	22.4
63	24.47	31.17	19.79		31.16	39.69	25.2
71	31.08	39.59	22.31		39.57	50.41	28.4
80	39.46	50.27	25.13		50.24	64.00	32.0
90	49.94	63.62	28.27		63.58	81.00	36.0
100	61.66	78.54	31.42		78.50	100.00	40.0
110	74.60	95.03	34.56		94.98	121.00	44.0
125	96.34	122.72	39.27		122.66	156.25	450.0
140	120.84	153.94	43.98		153.86	196.00	56.0
160	157.84	201.06	50.27		200.96	256.00	64.0
180	199.76	254.47	56.55		254.34	324.00	72.0
200	246.62	316.16	62.83		314.00	400.00	80.0

## **REGULAR POLYGON**

A =  $na^2/4$  cot ( $_\Pi$  /n) =  $nr^2$  tan ( $_\Pi$  /n)

=  $nR^2/2 \sin(2 \pi /n)$ 

n = no: of sides, a = side r= Radius of inscribed circle

R= Radius of circumscribed circle.

Name of	No.	Angle	Value of factor x					
Polygon	of sides	in Degrees	A=a²x	r=ax R= ax		Side a =R x	Side a =r x	
Triangle	3	60	0.433	0.289	0.577	1.732	3.464	
Tetragon	4	90	1.000	0.500	0.707	1.414	2.000	
Pentagon	5	108	1.721	0.688	0.861	1.176	1.454	
Hexagon	6	120	2.598	0.866	1.000	1.000	1.155	
Octagon	8	135	4.828	1.207	1.307	0.765	0.828	
Decagon	10	144	7.694	1.538	1.618	0.618	0.650	
Dodecagon	12	150	11.196	1.866	1.932	0.517	0.543	

#### AREA OF IRREGULAR PLANE FIGURES

Trapezoidal Rule

$$A = h \left[ \frac{y_0 + y_n}{2} + y_1 + y_2 + \dots + y_{n-1} \right]$$

Simpson's rule

$$A = h \Big[ \left( y_0 + y_n \right) + 4 \left( y_1 + y_3 + \ldots + y_{n-1} \right) + 2 \left( y_2 + y_4 + \ldots + y_{n-2} \right) \Big]$$

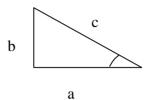
[Devide the area or figure into an even number 'n' of parallel strips by means of (n+1) ordinates paced equal distance]

equal distancej	

## TRIGONOMETRY

## **DEFINITION OF FUNCTION**

$$\begin{aligned} &\sin\theta = \frac{b}{c} \\ &\cos\theta = \frac{a}{c} \\ &\tan\theta = \frac{b}{a} = \frac{\sin\theta}{\cos\theta} \\ &\cos\theta = \frac{c}{b} = \frac{1}{\sin\theta} \\ &\sec\theta = \frac{c}{a} = \frac{1}{\cos\theta} \\ &\cot\theta = \frac{a}{b} = \frac{\cos\theta}{\sin\theta} = \frac{1}{\tan\theta} \end{aligned}$$



## **IMPORTANT IDENTITIES**

$$Sin^{2}\theta + Cos^{2}\theta = 1$$

$$1 + Tan^{2}\theta = Sec^{2}\theta$$

$$1 + Cot^{2}\theta = Cosec^{2}\theta$$

## Values of trigonometric function

Angle	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$
Sin	0	$\frac{1}{2}$	$\frac{1}{\sqrt{2}}$	$\sqrt{3}/2$	1
Cos	1	$\sqrt{3}/2$	$\frac{1}{\sqrt{2}}$	$\frac{1}{2}$	0
Tan	0	$\frac{1}{\sqrt{3}}$	1	$\sqrt{3}$	$\infty$
Cosec	$\infty$	2	$\sqrt{2}$	$\frac{2}{\sqrt{3}}$	1
Sec	1	$\frac{2}{\sqrt{3}}$	$\sqrt{2}$	2	$\infty$
Cot	$\infty$	$\sqrt{3}$	1	$\frac{1}{\sqrt{3}}$	0

#### FUNCTIONS OF SUM AND DIFFERENCE OF TWO ANGLES

$$Sin(A \pm B) = SinACosB \pm CosASinB$$

$$Cos(A \pm B) = CosACosB \mp SinASinB$$

$$Tan(A \pm B) = \frac{TanA \pm TanB}{1 \mp TanATanB}$$

$$\cot(A \pm B) = \frac{\cot A \mp \cot B}{\cot A + \cot B}$$

#### **FUNCTIONS OF SUM OF THREE ANGLES**

Sin(A+B+C) = SinACosBCosC + CosASinBCosC + CosACosBSinC - SinASinBSinC

Cos(A+B+C) = CosACosBCosC - SinASinBCosC - SinACosBSinC - CosASinBSinC

#### **FUNCTIONS OF MULTIPLE ANGLES**

$$\sin 2\theta = 2\sin\theta \cos\theta$$

$$\sin 3\theta = 3\sin \theta - 4\sin^2 \theta$$

$$Sin 4\theta = 8Cos^2\theta Sin\theta - 4Cos\theta Sin\theta$$

$$\cos 2\theta = \cos^2 \theta - \sin^2 \theta$$

$$\cos 3\theta = 4\cos^2\theta - 3\cos\theta$$

$$\cos 4\theta = 8\cos^4\theta - 8\cos^2\theta + 1$$

$$Tan2\theta = \frac{2Tan\theta}{1 - Tan^2\theta}$$

$$Tan3\theta = \frac{3Tan\theta - Tan^3\theta}{1 - 3Tan^2\theta}$$

## **FUNDAMENTAL RELATIONS**

Sine Law 
$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} = 2R$$
  $\log \sqrt[m]{x} = \frac{\log x}{m}$ 

Cosine Law 
$$a^2 = b^2 + c^2 - 2bcCosA$$

Tangent Law 
$$\frac{a+b}{a-b} = \frac{Tan \frac{A+B}{2}}{Tan \frac{A-B}{2}}$$

Projection Law 
$$a = bCosc + cCosB$$

$$Tan 4\theta = \frac{4Tan\theta - 4Tan^3\theta}{1 - 6Tan^2\theta + 4Tan^4\theta}$$

$$\cot 2\theta = \frac{\cot^2 \theta - 1}{2\cot \theta}$$

$$\cot 3\theta = \frac{\cot^3 \theta - 3\cot \theta}{3\cot \theta - 1}$$

$$\cot 4\theta = \frac{\cot^4\theta - 6\cot^2\theta + 1}{4\cot^3\theta - 4\cot\theta}$$

#### LAWS OF LOGARITHMS

 $\log 1 = 0, \log a = 1, \log (mn) = \log m + \log n$ 

$$\log \frac{m}{n} = \log m - \log n, \log m^n = n \log m$$

$$\log \sqrt[m]{x} = \frac{\log x}{x}$$

## INDICES

For Rational Values of m and n (if a, b are

$$a^m \times a^n = a^{m+n}, (ab)^m = a^m b^m$$

$$a^{0} = 1, \frac{a^{m}}{a^{n}} = a^{m-n}$$

## STRUCTURAL ENGINEERING

## Unit weight of Building materials [REF:IS 875 (Part 1) 1987]

SI. No	Material	Kg/m³
1	Aluminium (cast)	2580 - 2710
2	Bitumen	1040
3	Brick masonry (common burnt clay brick)	1920
4	Brick masonry (engineering bricks)	2400
5	Bricks	1600 - 1920
6	Broken bricks	1010 - 1450
7	Broken stone ballast- dry	1600 – 1870
	Broken stone ballast- wet	1920 - 2240
8	Cement	1440
9	Cement mortar	2080
10	Clay	1440 - 2080
11	Copper (cast)	8790 - 8940
12	Dry rubble masonry	2080
13	Earth (dry)	1410 - 1840
	Earth (wet)	1600 - 2000
14	Glass (solid)	2400 - 2720
15	Gold (cast)	19550 - 19330
16	Granite	2640 - 2800
17	Gravel (loose)	1600
	Gravel (rammed)	1920 - 2160
18	Gypsum powder	1410 - 1760
19	Laterite	2080 -2400
20	Lime concrete	1920
21	Lime mortar	1600 - 1840
22	Lime slaked	580 - 640
23	Lime stone	2400 - 2640
24	Lime unslaked	880 - 1040
25	Marble	2720
26	News paper in bundles	400
27	Paper (in bundles and rolls)	700
28	Plain cement concrete	880 - 1920
29	Plastics	1200 - 1380
30	Prestressed cement concrete	2400
31	Reinforced cement concrete	2310 - 2700
32	River sand	1840
33	Rubber	910 - 960
34	Sand (dry)	1540 – 1600
	Sand (wet)	1760 - 2000
35	Silver (cast)	10400 - 10490

36	Steel sheets, railway rails etc	4490
37	Stone masonry	2080 - 2700
38	Surkhi (Brick dust)	1010
39	Tar	1010
40	Thread in bundles	500
41	Timber Teak	640
42	Water (fresh)	1000
	Water (salty)	1025
		Kg/m²
43	Aluminium sheet/mm thickness	2.8
44	Asbestos cement sheeting (per m²)	
	Corrugated (6mm thick)	
	Semi-corrugated (6mm thick)	12 - 13
	Plain (5mm thick)	9.16
45	Copper sheet/mm thickness	8.7
46	Steel plate/mm thickness	8
	, '	
47	M.P tiles (per tile)	2 - 3 <b>kg/τile</b>

#### GALVANIZED IRON SHEETS (PLAIN AND CORRUGATED) (REF. IS 277:1985)

B.G		16	18	20	22	24
Thickness in r	mm	1.6	1.25	1.00	0.8	0.63
Mass per m <sup>2</sup>	Class I	13.31	10.50	8.60	7.03	5.7
	Class II	13.16	10.41	8.45	6.88	5.55
	Class III	13.01	10.26	8.30	6.73	5.40
	Class IV	12.94	10.19	8.22	6.66	5.32

Classification is based on thickness of Zinc coating. Class I refers to sheets 750 g of zinc coating/  $m^2$ .class II-600g. Class III-450g.Class IV 375g. Weight of corrugated sheets to be arrived at taking the weight of plane sheets used for the same. 660mm wide corrugated sheets are obtained from 750mm, plain sheets and 800 mm corrugated sheets from 900mm plain sheets. Sheets are supplied in 1.8, 2.2,2.5,2.8, 3.2 m length.

## LIVE LOADS ON FLOORS (Ref. IS 875(Part 1) 1987)

1.	Houses, hospitals, hostels	200 kg/m <sup>2</sup>
2.	Office floors	250-400 kg/m²
3.	Banks, Reading rooms	300 kg/m²
4.	Shop floors, work rooms, restaurants, auditoriums	400 kg/m <sup>2</sup>
5.	Warehouses, workshops, factories for	
	light wright loads, dance halls, waiting halls	500 kg/m²
6.	Warehouses, workshops and factories for	
	medium weight loads	750 kg/m²
7.	Warehouses, workshops and factories for	
	heavy weight loads, book stalls, libraries	1000 kg/m²



- Stairs balconies not liable to over-crowding
- Stairs balconies liable to over- crowding

300 kg/m<sup>2</sup> 500 kg/m<sup>2</sup>

## Live loads on Roofs

- Flat, sloping or curved upto 10<sup>0</sup> (a) Access provided

2.

- (b) Access not provided
- Sloping roof-slope greater than 10°

- 150 kg/m<sup>2</sup>
  - 75 kg/m<sup>2</sup> 75 kg/m<sup>2</sup>

## STRIPPING TIME FOR FORM WORK (REF: IS 456-2000)

No.	Type of form work	Minimum period before striking formwork
l	Vertical formwork to columns, walls, beams	16-24 hours
2	Soffit formwork to slabs (Props to be refixed immediately after removal of formwork)	3 days
}	Soffit formwork to beams (Props to be refixed immediately after removal of formwork)	7 days
	Props to slabs 1. Spanning upto 4.5 m 2. Spanning over 4.5 m	7 days 14 days
	Props to beams and arches]  1. Spanning upto 6 m	14 days
	2. Spanning upto 6 m	21 days
		1 4500 1 1 0

<sup>\*</sup> In normal circumstances where ambient temperature does not fall below 15°C and where Ordinary Portland Cement is used and adequate curing is done.

#### LIMIT STATE DESIGN OF SLAB

(Ref. IS 456 2000)

Slab is designed as a two way slab for critical case. Live load 3kN/m<sup>2</sup>, Concrete - M20. Fe 415 steel.

lx	thicknessT of slab	steel along span	j shorter	steel along longer span	
m	cm	ф	spacing	ф	spacing
3	10	8	170	8	240
3	12	8	210	8	240
3	14	8	220	8	240
3	15	8	230	8	240
3	17.5	8	230	8	240
3.5	10	8	120	8	240
3.5	12	8	140	8	240
3.5	14	8	160	8	240
3.5	15	8	170	8	240
3.5	17.5	8	190	8	240
3.5	20	8	200	8	240
4	10	10	130	8	180
4	12	10	160	8	210

4	14	10	190	8	240
4	15	10	200	8	240
4	17.5	10	220	8	240
4	20	10	240	8	240
4	22.5	10	240	8	240
4	25	10	260	8	240
4.5	12	10	120	8	160
4.5	14	10	140	8	190
4.5	15	10	150	8	200
4.5	17.5	10	170	8	240
4.5	20	10	180	8	240
4.5	22.5	10	190	8	240
4.5	25	10	200	8	240
5	12	12	130	10	200
5	14	12	160	10	230
5	15	12	170	10	240
5	17.5	12	190	10	240
5	20	12	210	10	240
5	22.5	12	220	10	240
5	25	12	230	10	240

## LIMIT STATE DESIGN OF SIMPLY SUPPORTED RECTANGULAR BEAM

(Ref. IS 456 2000)

Slab load 25kN/m, Concrete - M20; Fe 415 steel

Effective span	width	depth	steel at bottom	steel at top	
3	230	400	4,12	2,12	
3	230	450	4,12	2,12	
3	250	400	2,16	2,12	
3	250	450	4,12	2,12	
3	300	400	2,16	2,12	
3	300	450	4,12	2,12	
4	230	400	2,12+2,16	2,12	
4	230	450	3,16	2,12	
4	250	400	2,12+2,16	2,12	
4	250	450	3,16	2,12	
4	300	400	2,12+2,16	2,12	
4	300	450	3,16	2,12	
5	230	400	4,20	2,12	
5	230	450	5,16	2,12	
5	250	400	4,20	2,12	
5	250	450	5,16	2,12	
5	300	400	4,20	2,12	
5	300	450	4,18	2,12	
6	230	400	5,20	2,20+1,12	

6	230	450	4,20+1,12	3,14	
6	250	400	6,18	2,20	
6	250	450	4,20+1,16	3,12	
6	300	400	4,20+2,16	2,18	
6	300	450	3,25	2,12	

## LIMIT STATE DESIGN OF SQUARE COLUMN

(Ref. IS 456 2000) Concrete - M25 ; Fe 415 steel

size	1	nain bar	links I		load carried by the column (N)
	no.	Dia	Dia	spacing	
230x230	4	16	8	250	751703.9
230x230	4	20	8	250	876974.8
250x250	4	16	8	250	847703.9
250x250	4	20	8	250	972974.8
300x300	4	16	8	250	1122704
300x300	4	20	8	250	1247975
300x300	4	25	8	250	1443711
400x 400	4	16	8	250	1822704
400x 400	4	20	8	250	1947975
400x 400	4	25	8	250	2143711

## R.C.C. LINTELS FOR OPENINGS IN BRICK WALLS CONDITIONS OF LOADING

## Case I Height of wall - clear span/2

Tensile reinforcement (Fe 415 steel)-Add Stirrups & Stirrup holder					
clear	depth of	23 cm wall	34 cm wall	45 cm wall	
span	lintel	straight	straight	straight	
1	10	8mm, 2Nos	8mm, 2Nos	8mm, 2Nos	
1.5	14	8mm, 3Nos	8mm, 4Nos	10mm, 3Nos	
2	18	10mm,3Nos	10mm, 4Nos	12mm, 3Nos	
2.5	24	10mm, 3Nos	10mm, 4Nos	12mm, 3Nos	
3	35	12mm, 2Nos	16mm, 2Nos	16mm, 2Nos	
		Case II Height	of wall - clear span		
1	12	8mm, 3Nos	8mm, 3Nos	8mm, 4Nos	
1.5	18	10mm, 3Nos	10mm, 3Nos	10mm, 4Nos	
2	25	10mm,3Nos	12mm, 2Nos+ 10 mm, 1 No.	12mm, 2Nos+ 10 mm, 1 No.	
2.5	35	12mm, 2Nos + 10mm, 1 No.	16mm, 2Nos + 12 mm 1No.	16mm, 2Nos + 12mm 2Nos.	
3	48	14mm, 4Nos	14mm, 5Nos	16mm, 3Nos + 12 mm 2Nos.	

## SIZE OF MEMBERS FOR STEEL ROOF TRUSSES OF VARIOUS SPANS

Size of angle members in mm,roof slope 1 in 2, PR=Principal rafter

## 5meters span-Light Loading- 4 panels at 1.4meters

## Truss Spacing

Truss Spacing

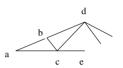
**Truss Spacing** 

Member	3 m	4 m	5 m
PR ad	2 ISA-50x30x6	2 ISA-50x30x6	2 ISA-50x30x6
dc,bc,ce,ac	1 ISA-50x30x6	1 ISA-50x30x6	1ISA-50x30x6

## 5m span- Medium Loading -4panels at 1.4m

Member	3M	4 M
PR ad,	2 ISA-50X30X6	2 ISA-50X30X6
TIE- ac	1 ISA-50X30X6	1 ISA-65X45X6
dc,bc,ce	1 ISA-50X30X6	1 ISA-50X30X6
Diameter of rivets-	16mm,thickness of gussets	s- 10mm and 6mm

6meters span-Light Loading- 4 panels at 1.8meters



		Truss Spacing
Member	3 M	4 M
PR ad	2 ISA-50X30X6	2 ISA-50X30X6
TIE- ac	1 ISA-50X30X6	1ISA-50X30X6
dc,bc,ce	1 ISA-50X30X6	1ISA-50X30X6

6m span- Medium Loading -4panels at 1.8meters

d
1
b

2 ISA-50X30X6 1ISA-50X30X6 1ISA-50X30X6

5M

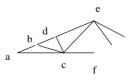
Member	3M	4 M
PR ad,	2 ISA-50X30X6	2 ISA-50X30X6
TIE-ac	1 ISA-50X50X6	1 ISA-65X45X6
dc,bc,ce	1 ISA-50X30X6	1 ISA-50X30X6
Diameter of rivets-	16mm, thickness of gussets-	10mm and 6mm

## 7.5meters span-Light Loading- 6 panels at 1.4meters

	Truss Spacing				
Member	3 M	4 M	5M		
PR ae	2 ISA-50X30X6	2 ISA-50X30X6	2 ISA-50X30X6		
Tie(end)- ac	1 ISA-50X30X6	1 ISA-65X45X6	1 ISA-75X50X6		
Tie(central)- cf	1 ISA-50X30X6	1 ISA-50X30X6	1 ISA-50X30X6		
bc	1 ISA-50X50X6	1 ISA-50X50X6	1 ISA-50X50X6		
ec.dc	1 ISA-50X30X6	1 ISA-50X30X6	1 ISA-50X30X6		

#### 7.5METERS SPAN-MEDIUM LOADING- 6 PANELS AT 1.4METERS

		Truss Spacing
Member	3M	4 M
PR ae	2 ISA-50X30X6	2 ISA-50X30X6
Tie(end)- ac	2 ISA-50X30X6	2 ISA-50X30X6
Tie(central)- cf	1 ISA-50X30X6	1 ISA-50X30X6
bc	1 ISA-50X50X6	1 ISA-50X50X6
ec, <b>d</b> c	1 ISA-50X30X6	1 ISA-50X30X6
Diameter of rivets-	<ul> <li>16mm thickness of gussets</li> </ul>	s- 10mm and 6mm



## 9 meters span-Light Loading- 6 panels at 1.68meters

		Truss Spacing	
Member	3 M	4 M	5M
PR ae	2 ISA-50x30x6	2 ISA-50x50x6	2 ISA-65x45x6
Tie(end)- ac	1 ISA-65x45x6	1 ISA-75x50x6	1I SA-50x30x6
Tie(central)- cf	1 ISA-50x30x6	1 ISA-50x30x6	1I SA-50x30x6
bc	1 ISA-50x50x6	1 ISA-50x50x6	1I SA-50x50x6
ec,dc	1 ISA-50x30x6	1 ISA-50x30x6	1I SA-50x30x6

## 9 Meters Span-medium Loading- 6 Panels At 1.68meters

		Truss Spacing
Member	3 M	4 M
PR ae	2 ISA-65X45X6	2 ISA-65X45X6
Tie(end)- ac	2 ISA-50x30x6	2 ISA-50x30x6
Tie(central)- cf	1 ISA-50x30x6	1 ISA-65x45x6
bc	1 ISA-65x45x6	1 ISA-65x45x6
ec,d c	1 ISA-50x30x6	1 ISA-65x45x6

Diameter Of Rivets- 16mm, Thickness Of Gussets- 10mm And 6mm

## 12 Meters Span-light Loading- 8 Panels At 1.68meters

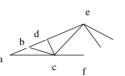
		Truss Spacing	
Member	3 m	4 m	5 m
PR ah	2 ISA-50x30x6	2 ISA-65x45x6	2 ISA-75X50X6
Tie(end)- ac	2 ISA-50x30x6	2 ISA-50X30X6	2 ISA-50X30X6
Tie(central)- ej	1 ISA-50x30x6	1 ISA-50X50X6	1 ISA-65X45X6
fg,he	1 ISA-50x30x6	1 ISA-50X50X6	1 ISA-65X45X6
de	2 ISA-50x30x6	2 ISA-50X30X6	2 ISA-50X30X6
bc,dg,bc	1 ISA-50x30x6	2 ISA-50X30X6	2 ISA-50X30X6

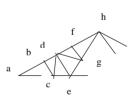
## 12meters Span-medium Loading- 8 Panels At 1.68meters

		Truss Spacing
Member	3 m	4 m
PR ah	2 ISA-75x50x6	2 ISA-75x50x6
Tie(end)- ac	2 ISA-50x30x6	2 ISA-50x50x6
Tie(central)- ej	1 ISA-65x45x6	1 ISA-75x50x6
fg,he	1 ISA-75x50x6	1 ISA-90x60x6
de	2 ISA-50x30x6	2 ISA-50x30x6
dc,dg,bc	1 ISA-50x30x6	1 ISA-50x30x6
Diameter Of Rivets-	16mm.Thickness Of	Gussets- 10mm And 6mm

## 15 Meters Span-light Loading- 12 Panels At 1.5meters

		Truss Spacing	
Member	3 m	4 m	5 m
PR Ak	2 ISA-65X45X6	2 ISA-75X50X6	2 ISA-90X60X6
Tie(end)- af	2 ISA-50X30X6	2 ISA-50X30X6	2 ISA-50X50X6
Tie(central)- fi	1 ISA-75X50X6	1 ISA-75X50X6	1 ISA-90X60X6
fk	1 ISA-75X50X6	1 ISA-75X50X6	1 ISA-90X60X7
bc,dc,gh,jh	1 ISA-50X30X6	1 ISA-50X30X6	1 ISA-50X50X6
ef,ce,eh	2 ISA-50X30X6	2 ISA-50X30X6	2 ISA-50X50X6





## 15meters Span-medium Loading- 12 Panels At 1.5meters

		Truss Spacing		
Member	3 m	4 m		
PR ak	2 ISA-75X50X6	2 ISA-90X60X6		. k
Tie(end)- af	2 ISA-65X45X6	2 ISA-75X50X6		g J
Tie(central)- fi	2 ISA-50X30X6	2 ISA-50X30X6	, e ,	
fk	2 ISA-50X30X6	2 ISA-50X30X6	b d	h
bc,dc,gh,jh	1 ISA-50X30X6	1 ISA-50X30X6	a	
ef,ce,eh	2 ISA-50X30X6	2 ISA-50X30X6	c	f
Diameter Of Rivets-	16mm, Thickness Of Gu	ssets- 12mm And 8mm		

c. size of members of tubular steel roof trusses of various spans
Light loading with roof slope 1 in 3,PR=Principal rafter,L=light, M=medium
and Size is 'nominal bore' Class C pipe

5 to 6 metres spa	ın		
	_	Truss Spacing	d
Member	3 m	4 m	5m
PR-ad	32 mm-L	32 mm-L	32 IIIII-L / \ \ \
	32 mm-L	32 mm-L	32 mm-L
	15 mm-L	15 mm-L	15 mm-L <sup>a</sup> c e
7.5 metres span			
		Truss Spacing	d
Member	3 m	4 m	5m c .
P R-ae	40 mm-L	40 mm-M	50 mm-L b
Tie beam-af	32 mm-L	32 mm-M	40 mm-L
bc,dc,df	20 mm-L	20 mm-L	15 mm-L
ef	15 mm-L	15 mm-L	15 mm-L <sub>a</sub> f e
10 metres span			_
•		Truss Spacing	
Member	3 m	4 m	5m
P R-ah	40 mm-M	50 mm-M	50 mm-M
Tie beam-aj	40 mm-L	50 mm-L	50 mm-L
dc,dg,de,bc	20 mm-L	25 mm-L	25 mm-L b 1
he	32 mm-L	20 mm-L	20 mm-L a c f
hj	15 mm-L	20 mm-L	20 mm-L
12 metres span			
•		Truss Spacing	
Member	3 m	4 m	5m
P R-ah	50 mm-M	65 mm-M	65 mm-M
Tie beam-aj	40 mm-M	50 mm-M	50 mm-M b d f
dc,dg,de,bc	20 mm-M	25 mm-M	25 mm-M
he	32 mm-M	40 mm-M	40 mm-M a
hj	15 mm-M	20 mm-M	20 mm-M <sup>° ce</sup> <sup>J</sup>
15 metres span			
· ·		Truss Spacing	
Member	3 m	1 m	5 m

uc,ug,uc,bc	ZU IIIIII-IVI	ZJ IIIIII-W	23 11111-101
he	32 mm-M	40 mm-M	40 mm-M a
hj	15 mm-M	20 mm-M	20 mm-M <sup>°° ce</sup>
15 metres span			
		Truss Spacing	
Member	3 m	4 m	5 m
P R-ak	65 mm-M	65 mm-M	65 mm-M
Tie beam-ai	65 mm-M	80 mm-M	80 mm-M
de,bc,gh,jh	25 mm-L	25 mm-L	25 mm-L
ef,ce,eh	25 mm-L	32mm-L	40 mm-M
kf	65 mm-M	65 mm-M	65 mm-M "
ki	40 mm-M	40 mm-M	40 mm-M

#### **SLAB FOR CULVERTS**

M25 Concrete Fe 415 Steel Bearing width = 0.5m

Class A loading 2 lane traffic with 1 m foot path on both sides

Clear	Overall		Main Reinforc	ement Bar	Di	stribution Ba	rs
Span (m)	depth (mm)	Area (cm²)	Diameter (mm)	Spacing (mm)	Area (cm²)	Diameter (mm)	Spacing (mm)
1	180	8.62	10	90	2.52	8	200
1.5	200	9.37	10	80	2.70	8	180
2	250	9.67	12	110	3.15	8	160
3	320	11.18	12	100	3.84	8	130
4	400	12.12	12	90	4.8	10	160
5	460	14.54	14	100	5.52	10	140
6	540	15.93	16	120	6.48	10	120

#### Slab for culvert as per MoRTH type Design

Clear	depth		Main Rei	nforceme	nt bar	Dis	tributio	on Bar
span	(mm)		Location	Dia	Spac-	Location	Dia	Spacing
(m)	at Edge	at Centre			ing			
3	300	450	bottom	16	180	bottom	8	150
3	300	430	top	10	290	top	o 10	580
4	350	500	bottom	16	140	bottom	10	200
			top	10	250	top	10	500
5	400	550	bottom	20	160	bottom	10	125
			top	10	225	top	10	450
6	450	600	bottom	20	125	bottom	12	175
			top	10	220	top	10	440

#### PRESTRESSED CONCRETE

Prestressed concrete is one in which permanent internal stresses are deliberately introduced, usually by tensioned steel to counteract to the desired degree, the stresses caused in the member in service. It is of two categories – Pre tensioning and post tensioning. In pre tensioning, the tendons are tensioned before casting the concrete while in post tensioning, the reinforcement is tensioned after the concrete has fully hardened.

#### Losses in Prestress

1.Loss due to creep of concrete =  $\phi\sigma con \times m$ 

Where  $\sigma$  con- compressive stress in concrete at the level of steel

 $\phi$  - creep coefft.

m – modular ratio

= Young's modulus of steel / Young's modulus of concrete

- 2. Loss of prestress due to shrinkage of concrete=  $E_{\scriptscriptstyle S}$  × shrinkage strain of concrete  $E_{\scriptscriptstyle S}$  = Modulus of Elasticity of steel
- 3 Loss of prestress due to relaxation of steel

Relaxation Losses For Prestressing Steel a 27 <sup>0</sup> C

Initial Stress	Relaxation Loss(N/mm <sup>2</sup>
0.5f <sub>n</sub>	0
$0.6f_{p}^{P}$	35
$0.7f_{p}^{P}$	70
0.5f <sub>p</sub> 0.6f <sub>p</sub> 0.7f <sub>p</sub> 0.8f <sub>p</sub>	90
P	

 $f_p$  is the characteristic strength of prestressing steel

4. Loss of prestress due to Elastic shortening of concrete

=m  $\sigma$  in pretensioning

$$= m \times \left(\frac{\sigma_c}{2}\right) \text{in post tensioning}$$

)

 $\sigma_c$  = stress in concrete at the level of steel

5. Loss of prestress due to slip in anchorage = 
$$\frac{\delta l}{l} \times E_S$$

$$\delta l = slip$$

*I*=length of cable

6.Loss due to friction 
$$P_{_{_{X}}}=P_{_{0}}e^{-\left(\mu\alpha+kx
ight)}$$

 $P_0$  =prestressing force in the prestressed steel at the tensioning end acting in the direction of the tangent to the curve of the cable

 $\alpha$  =cumulative angle in radians through which the tangent to the cable profile has turned between any two points under consideration

 $\mu$  =coefficient of friction in curve

k =coefficient for wave effect varying from 0.0015 to 0.005 per metre

#### PROPERTIES OF FRESH & HARDENED CONCRETE

#### 1. FRESH CONCRETE

To ensure that the hardened concrete is acceptable in its performance, the fresh concrete must satisfy the following:

- 1. It must be easily mixed and transported,
- 2. It must be uniform throughout a batch and between batches,
- 3. It must flow adequately that it fills the forms
- 4. It must be able to be compacted fully without excessive energy,
- 5. It must not segregate during placement and compacted
- 6. It must be able to be finished properly, either by trowelling or within the formwork

#### Workability

It is defined as the ease with which concrete can be transported, handled, ?placed and ?finished.

#### 1.1 Factors Affecting Workability

- Water content of the mix
- Influence of Aggregate Mix Proportions
- Aggregate Properties
- Temperature and Time
- Cement Characteristics
- **1.2 Segregation:** of the components in the mix resulting in a non uniform mix.. For example, if a mix is subject to excessive vibration, the coarse aggregate will settle to the bottom, and the paste will rise to the top.

This can occur during mixing, placement, or compaction.

#### Factors contributing to segregation:

- Large maximum particle size (>25 mm),
- Large proportion of large aggregate,
- High specific gravity of coarse aggregate,
- Decreased amount of fines (sand or cement),
- Increased irregular shape or rough texture, and
- Mixes that are too wet or too dry.

The tendency to segregate can be overcome, in part at least, by careful handling.

**1.3 Bleeding:** appearance of water on the surface of the concrete after it has been consolidated but before it has set. This is a special form of segregation. It can lead to a weak, porous surface. Excessive bleeding can damage the concrete structure. Bleed water can form channels in the concrete, and may develop small craters on the surface where the channel surfaces. This leads to weakness, increased porosity and permeability, and reduced durability.

Bleed water may accumulate beneath large aggregate or reinforcing generating weak zones and reducing bond.

If bleed water on the surface evaporates more rapidly that bleeding rates (in hot or dry weather) plastic shrinkage cracks can form, and the paste at the surface may not adequately hydrate, causing dusting and reduced durability of the wearing surface.

Bleeding can be reduced by:

- 1. Increasing the cement fineness or using pozzolans or other finely divided mineral admixtures.
- 2. Increasing the rate of hydration by using cements with high alkali contents or high C3A contents
- 3. By air entrainment (very effective)
- 4. Reducing the water content (as long as adequate workability is maintained).
- **1.4 Setting:** the onset of rigidity in fresh concrete, distinct from *hardening* which is the change in measurable strength. Set precedes hardening.

**Initial Set:** when paste begins to stiffen considerably. Defined by Vicat Needle, penetration 5 to 7 mm from bottom of the mould. Typical values not less than 30 minutes

**Final Set:** when paste has hardened to the point at which it can sustain some load. Defined by Vicat Needle time of 0 penetration into paste; Typical values not more than 600 minutes.

False Set: rapid stiffening of the concrete shortly after mixing without evolution of much heat. Fluidity can be restored by remixing with no water addition, after which the concrete may set normally.

Flash Set: rapid development of rigidity with evolution of considerable heat. Rigidity cannot be overcome only by mixing and plasticity cannot be regained without addition of water

#### 2. HARDENED CONCRETE

It is concerned with the following characteristics - Strength,??Durability, and Volume Stability

#### 2.1 Strenath

The primary function of concrete is to carry applied loads, expressed in terms of strength

#### Factors affecting strength

1. Constituent Materials

Cement Type

Cement Content

Proportions of Constituents

Aggregates

- 2. Methods of Preparation
- 3. curing condition

Moisture

Temperature

4. Test Conditions

#### 2.1.1. Compressive strength

This is the most significant parameter of concrete which is standardized by cube tests. Characteristic compressive strength of concrete is defined as the 28 day compressive strength of 150mm size concrete cubes and that value below which not more than five percent of the test result is expected to fall.

#### Grades of concrete (Ref. IS 456:2000 Table 2)

Group	Grade Designation	Specified characteristic compressive strength of 150mm cube at 28 days in N/mm <sup>2</sup>
Ordinary concrete	M 10	10
-	M15	15
	M20	20
Standard concrete	M25	25
	M30	30
	M35	35
	M40	40
	M45	45
	M50	50
	M55	55
High Strength Concrete	* M60	60
	M65	65
	M70	70
	M75	75
	M80	80

<sup>\*</sup> For the concrete of compressive strength greater than M55, design parameter given in the standard may not be applicable and the values may be obtained from specialized literatures and experimental results.

#### 2.1.3 Modulus of Elasticity

This hardened property of concrete is normally related to the compressive strength of concrete.

$$Ec = 5000\sqrt{f_{ck}}$$

Where Ec is the short term static modulus of elasticity in N/mm<sup>2</sup>

#### 2.1.2 Tensile strength

Concrete has low tensile strength ~10% of its compressive strength. Testing for tensile strength is typically done using the cylinder tensile splitting test or modulus of rupture.

#### 2.1.3. Flexural strength

Due to bending of a member where in compression occurs on one side and tension on another.

Flexural strength 
$$f_{cr} = 0.7 \sqrt{f_{ck}} N / mm^2$$

Flexural strength  $f_{cr}=0.7\sqrt{f_{ck}}\,N\,/\,mm^2$  Where  $f_{ck}$  is the characteristic compressive strength of concrete in N/mm²

#### 2.1.4. Shear strength

Concrete seldom experiences pure shear. When subject to bending there is usually a shear component in the stress

#### 2.1.5. Bond strength

Both cementitious bond to aggregate and to re-ba. Bond strength increases with compressive strength .Bond strength is higher for deformed bar than for plain bars

#### Factors affecting strength

- 1. Constituent Materials
  - Cement Type
  - Cement Content
  - Proportions of Constituents
  - Aggregates
- 2. Methods of Preparation
- 3. Curing Procedures
  - Moisture
  - Temperature
- 4. Test Conditions

#### 2.2 Durability

Includes the following types of behaviour

- weathering
- \* reaction with aggregate
- \* attack by sulphates
- efflorescence
- \* reaction with organic chemicals
- corrosion of steel
- ❖ wear
- permeability

#### 2.3 Volume Stability

#### 2.3.1Shrinkage:

The total shrinkage of concrete depends upon the constituents of concrete, size of the member and environmental conditions. For a given humidity and temperature, total shrinkage of concrete is most influenced by the total amount of water present in the concrete at the time of the mixing and to a lesser extend by the cement content. In the absence of test data, the approximate value of the total shrinkage strain for design may be taken as 0.0003.

#### 2.4.1 Creep:

The creep of concrete depends upon the constituents of concrete, size of the member, environmental conditions, stress in the concrete, age at loading and duration of loading. Indirectly creep is calculated from creep coefficient (that is, Ultimate creep strain / Elastic strain at the age of loading).

Age at loading	Creep coefficient
7 days	2.2
28 days	1.6
I year	1.1

#### **CONCRETE MIX DESIGN**

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible, is termed the concrete mix design. The proportioning of ingredient of concrete is governed by the required performance of concrete in 2 states, namely the plastic and the hardened states. If the plastic concrete is not workable, it cannot be properly placed and compacted. The property of workability, therefore, becomes of vital importance.

The compressive strength of hardened concrete which is generally considered to be an index of its other properties, depends upon many factors, e.g. quality and quantity of cement, water and aggregates; batching and mixing; placing, compaction and curing. The cost of concrete is made up of the cost of materials, plant and labour. The variations in the cost of materials arise from the fact that the cement is several times costly than the aggregate, thus the aim is to produce as lean a mix as possible. From technical point of view the rich mixes may lead to high shrinkage and cracking in the structural concrete, and to evolution of high heat of hydration in mass concrete which may cause cracking.

The actual cost of concrete is related to the cost of materials required for producing a minimum mean strength called characteristic strength that is specified by the designer of the structure. This depends on the quality control measures, but there is no doubt that the quality control adds to the cost of concrete. The extent of quality control is often an economic compromise, and depends on the size and type of job. The cost of labour depends on the workability of mix, e.g., a concrete mix of inadequate workability may result in a high cost of labour to obtain a degree of compaction with available equipment.

#### Requirements of concrete mix design

The requirements which form the basis of selection and proportioning of mix ingredients are :

- a ) The minimum compressive strength required from structural consideration
- b) The adequate workability necessary for full compaction with the compacting equipment available.
- Maximum water-cement ratio and/or maximum cement content to give adequate durability for the particular site conditions
- d) Maximum cement content to avoid shrinkage cracking due to temperature cycle in mass concrete.

#### Types of Mixes

#### 1. Nominal Mixes

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

#### 2. Standard mixes

The nominal mixes of fixed cement-aggregate ratio (by volume) vary widely in strength and may result in under- or over-rich mixes. For this reason, the minimum compressive strength has been included in many specifications. These mixes are termed standard mixes.

IS 456-2000 has designated the concrete mixes into a number of grades as M10, M15, M20, M25, M30, M35 and M40. In this designation the letter M refers to the mix and the number to the specified 28 day cube strength of mix in N/mm2. The mixes of grades M10, M15, M20 and M25 correspond approximately to the mix proportions (1:3:6), (1:2:4), (1:1.5:3) and (1:1:2) respectively.

#### 3. Designed Mixes

In these mixes the performance of the concrete is specified by the designer but the mix proportions are determined by the producer of concrete, except that the minimum cement content can be laid down. This is most rational approach to the selection of mix proportions with specific materials in mind possessing more or less unique characteristics. The approach results in the production of concrete with the appropriate properties most economically. However, the designed mix does not serve as a guide since this does not guarantee the correct mix proportions for the prescribed performance.

For the concrete with undemanding performance nominal or standard mixes (prescribed in the codes by quantities of dry ingredients per cubic meter and by slump) may be used only for very small jobs, when the 28-day strength of concrete does not exceed 30 N/mm2. No control testing is necessary reliance being placed on the masses of the ingredients.

#### Factors affecting the choice of mix proportions

The various factors affecting the mix design are:

#### 1. Compressive strength

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

## 2. Workability

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

#### 3. Durability

The durability of concrete is its resistance to the aggressive environmental conditions. High strength concrete is generally more durable than low strength concrete. In the situations when the high strength

is not necessary but the conditions of exposure are such that high durability is vital, the durability requirement will determine the water-cement ratio to be used.

#### 4. Maximum nominal size of aggregate

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

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

#### 5. Grading and type of aggregate

The grading of aggregate influences the mix proportions for a specified workability and water-cement ratio. Coarser the grading leaner will be mix which can be used. Very lean mix is not desirable since it does not contain enough finer material to make the concrete cohesive.

The type of aggregate influences strongly the aggregate-cement ratio for the desired workability and stipulated water cement ratio. An important feature of a satisfactory aggregate is the uniformity of the grading which can be achieved by mixing different size fractions.

#### 6. Quality Control

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

#### Mix Proportion designations

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

## Factors to be considered for mix design

- ⇒ è The grade designation giving the characteristic strength requirement of concrete.
- $\Rightarrow$  The type of cement influences the rate of development of compressive strength of concrete.
- ⇒ Maximum nominal size of aggregates to be used in concrete may be as large as possible within the limits prescribed by IS 456:2000.
- ⇒ The cement content is to be limited from shrinkage, cracking and creep.
- ⇒ The workability of concrete for satisfactory placing and compaction is related to the size and shape of section, quantity and spacing of reinforcement and technique used for transportation, placing and compaction.

#### **Procedure**

 Determine the mean target strength ft from the specified characteristic compressive strength at 28day fck and the level of quality control.

#### $ft = f_{ck} + 1.65 S$

where S is the standard deviation obtained from the Table of approximate contents given after the design mix.

2. Obtain the water cement ratio for the desired mean target using the emperical relationship between

compressive strength and water cement ratio so chosen is checked against the limiting water cement ratio. The water cement ratio so chosen is checked against the limiting water cement ratio for the requirements of durability given in table and adopts the lower of the two values.

- 3. Estimate the amount of entrapped air for maximum nominal size of the aggregate from the table.
- Select the water content, for the required workability and maximum size of aggregates (for aggregates in saturated surface dry condition) from table.
- 5. Determine the percentage of fine aggregate in total aggregate by absolute volume from table for the concrete using crushed coarse aggregate.
- Adjust the values of water content and percentage of sand as provided in the table for any difference in workability, water cement ratio, grading of fine aggregate and for rounded aggregate the values are given in table.
- 7. Calculate the cement content form the water-cement ratio and the final water content as arrived after adjustment. Check the cement against the minimum cement content from the requirements of the durability, and greater of the two values is adopted.
- 8. From the quantities of water and cement per unit volume of concrete and the percentage of sand already determined in steps 6 and 7 above, calculate the content of coarse and fine aggregates per unit volume of concrete from the following relations:

$$V = \left[W + \frac{C}{S_c} + \frac{1}{p} \frac{f_a}{S_{fa}}\right] \times \frac{1}{1000}$$

$$V = \left[W + \frac{C}{S_c} + \frac{1}{1-p} \frac{C_a}{S_{ca}}\right] \times \frac{1}{1000}$$

where V = absolute volume of concrete

= gross volume (1m3) minus the volume of entrapped air

Sc = specific gravity of cement

W = Mass of water per cubic metre of concrete, kg

C = mass of cement per cubic metre of concrete, kg

p = ratio of fine aggregate to total aggregate by absolute volume

fa, Ca = total masses of fine and coarse aggregates, per cubic metre of concrete, respectively, kg, and

Sfa, Sca = specific gravities of saturated surface dry fine and coarse aggregates, respectively

- 9. Determine the concrete mix proportions for the first trial mix.
- 10. Prepare the concrete using the calculated proportions and cast three cubes of 150 mm size and test them wet after 28-days moist curing and check for the strength.
- 11. Prepare trial mixes with suitable adjustments till the final mix proportions are arrived at.

#### **MASONRY STRUCTURES**

#### Stresses In Brick Masonry

 As a general rule, no tension shall be allowed in masonry. However under very exceptional circumstances tensile stress in bending upto 1 kg/cm2 shall be permitted. In case of walls built in mortar not weaker than 1:1:6 cement lime, sand mix, the permissible shear stress on the area of the horizontal mortar joint shall be taken as 1.5 kg/ cm2.

## GENERAL SPECIFICATIONS FOR MASONRY Stone Masonry

- Stones used in the face shall not be less than 15 cm wide in plan for 40 cm. thick walls and 22.5 cm. wide for 60 cm. thick walls.
- 2. Face stones shall be laid as headers and stretchers alternately to break joints by atleast 7.5 cm.
- 3. Stones shall be solidly bedded set full in mortar with mortar joints not exceeding 1.25cm in thickness
- 4. No pinning shall be allowed on face.
- 5. Height of stone shall not exceed length or breadth.
- Bushings shall not project from the face of wall for more than 3.5 cm. for walls to be pointed and 1.5 cm. for walls to be plastered.
- For walls upto 60 cm. thick bond stones shall extend to the full width of wall.
   For walls more than 60 cm. thick a line of stretchers shall be laid from face to back each one overlapping the other by atleast 15 cm
- 8. All stones and chips shall be washed clean before use. They shall be sprinkled with water before actually being placed in position.
- 9. All masonry shall be kept watered for 3 weeks.
- 10. Chips shall be wedged in wherever possible to avoid thick beds of mortar.

#### **Brick Masonry**

- 1. Bricks should be soaked in water for one hour before being used in cement or lime mortar
- 2. The masonry should be kept wet for 10 days.
- 3. No major joints should exceed 6 mm. for 1st class brick in cement and 10 mm. for 2nd class brick work in lime and 12 mm. for 3rd class brick work in mud mortar.
- Mortar of the proper consistency only should be used. Any subsequent thinning should be prohibited.
- 5. If the mortar in any course has started to set the joints should be raked out to a depth of 12 mm. before another course is laid. Where resuming the work after a lapse of time the top portion should be removed and surface cleaned before proceeding the work. The wall should be built up uniformly and no portion of the work shall be left 90 cm. lower than another portion.

#### Structural Design Of Load Bearing Walls

The thickness of wall is dependent on two factors:

- 1. The load to be carried in conjunction with the safe permissible stresses; and
- 2. The slenderness ratio of the wall.

For walls slenderness ratio is effective height divided by effective thickness, or effective length divided by effective thickness whichever is less.

## **BUILDINGS**

## STANDARDS OF SPACE ALLOTMENT FOR VARIOUS TYPES OF BUILDINGS

1	Schools Primary: Class room area secondary	1 sqm./student 1 sqm./student
2.	Arts and science colleges	
	Lecture halls	1 sqm./student
	Laboratories	2.3 sqm./student
3.	Student Hostels	
	Single seat rooms	9 sqm./student
	Double seat rooms	6.5 sqm./student
	Trible seat rooms	6.5 sqm./student
	Dormitories	4.5 sqm./student
4	Hospitals ward	7.5 sqm per patient
5.	Tourist Bunglows	
	(Economy class) single rooms	11 sqm excluding toilet
	Double rooms	17 sqm excluding toilet
	Upper class single rooms	14sqm excluding toilet and
		sit out
	Double rooms	18.5 sqm excluding toilet and
,	Office	sit out
6	Offices Gazetted officers below the rank of an AG or controller	1/0 oaft
	Non Gazetted staff	160 sqft 40 sqft
	records	10% of item ii
	Water closet 100cm x 150 cm	10 % Of Refff II
	males	1 for the first 40 persons & 1
	maios	for every 100 and part thereof.
	females	1 for the first 20 persons & 1
		for every 50 and part thereof.
	Urinals-60cm x 75 cm	, ,
	males	1 for the first 50 persons or
		part there of
	Dining room	10 sqft per person for half the
		numberof occupants

## WIDTH AND LENGTH OF MEANS OF ACCESS.

The residential plots shall abut on a public means of access like street/road. Plots which do not abut on a street/road shall abut/front on a means of access, the width and other requirements of which shall be as given in clause 4 of National Building Code.

## 3.4. SIDE AND REAR OPEN SPACES FOR DIFFERENT HEIGHTS OF BUILDINGS

SI. No.	Height of Buildings	Side & Rear open spaces to be left around the building
1	10	3
2	15	5

:	}	18	6
4	ļ	21	7
į	;	24	8
6	)	27	9
-	1	30	10
8	}	35	11
(	)	40	12
•	0	45	13
•	1	50	14
-	2	53& above	16

For buildings above 24m in height, there shall be a minimum front open space of 6m.

#### **CLEARANCE FROM OVER HEAD ELECTRIC LINES**

SI.No	Type of Electric Supply line	Vertical clearance in meters	Horizontal Clearance In mete.rs
1	Low & Medium Voltage lines	2.4	1.2
2	High voltage lines upto & including 33,000volts	3.7	1.85
3	Extra high voltage lines>33,000 volts	3.7 plus 0.3 m for every additional 33,000volts part thereof	1.85 Plus 0.3 m for every or additional 33,000volts or part thereof.

#### REQUIREMENTS OF PARTS OF BUILDINGS

#### 1) Plinth.

Main buildings-The plinth or any part of a building shall be so located with respect to the surrounding ground level that adequate drainage of the site is assured. The height of plinth shall not be less than 45cm from the surrounding ground level.

Interior ourtyards- Every interior courtyard shall be raised atleast 15cm above the level of the centre of the nearest street and shall be satisfactorily drained.

## 2) Habitable rooms.

Residential, Business & Mercantile buildings-

The height of all rooms for human habitation shall not be less than 2.75 m measured from the surface of the floor to the lowest point of the ceiling.

Educational buildings- Ceiling height 3.6m for all regions; in cold regions, 3m.

Industrial buildings- ceiling height 3.6m, except when air conditioned,3m

#### 3) Bathrooms&Water closets

The height of the bathroom/WC measured from the surface of the floorc to the lowest point in theceiling shall not be less than 2m.

## 4) Ledge or Tand/Loft

It shall have a minimum head room of 2.2 m. The maximum height of loft shall be 1.5m.

## 5) Garage

The height of the garage shall be not less than 2.4m. The size of the garage shall be as: private garage  $2.5 \times 5.0 \text{ m (min)}$ Public garage Based on the no of vehicles parked

#### 6) Chimneys

The chimneys shall be built atleast 0.9m above the flat roofs. In the case of sloping roofs, the chimney top shall not be less than 0.6m above the ridge of the roof in which the chimney penetrates.

#### 7) Parapet

Parapet walls and handrails provided on the edges of the roof terraces, balcony, varadah, etc shall not be less than 1.05m and not more than 1.2m in height from the finished floor level.

#### **FLOOR AREA RATIO**

#### Coverage and Floor Area Ratio(F.A.R.)

SI. No	Building use/ Occupancy	Max.Permissible Coverage	Max.Permissible F.A.R(without additional fee)	Max.Permissible F.A.R(with additional fee)
1	Residential A1	65	3	4
2	Spl.residential A2	65	2.5	4
3	Educational B	35	2.5	3
4	Medical/Hospital C	40	2	3
5	Assembly D	40	1.5	2.5
6	Office/Business E	40	2	3
7	Mercantile/Commercial F	65	2.5	4
8	Industrial G1	40	1.5	0
9	Small Industrial G2	60	2.5	3
10	Storage H	60	2.5	3
11	Hazardous I1	30	1	0
12	Hazardous 12	25	0.7	0

#### **RAMPS-DEATILS**

Ramps if provided as a substitute for stairways shall be laid with a slope not exceeding 1 in 10 and such ramp shall comply with all requirements of a stairway and shall be surfaced with approved non-slippery materials.

#### WELLS- LOCATION AND REQUIREMENTS

Location-The well shall be located :

- a) not less than 15 m from any ash pit, refuse pit, earth closet or privy and shall be located on a site upwards from the earth closet or privy;
- b) not less than 18m from any cess pit soakway or borehole latrine and shall be located on a site upwards from the earth closet or privy;
- c) that contamination by the movement of sub soil or other water is unlikely.

#### Requirements- The well shall:

- a) Have a minimum internal diameter of not less than 1m;
- b) Be constructed to height not less than 1m above the surrounding ground level.
- c) Be of sound and permanent construction throughout. Temporary or exposed wells shall be permitted only in fields or gardens for purposes of irrigation; and
- d) Have the interior surface of the lining or walls of the well be rendered impervious for a depth of not less than 1.8m measured from the level of the ground immediately adjoining the well-head.

## REQUIREMENTS OF CEMENT FOR DIFFERENT WORKS

Ref. Schedule	Particulars	Quantity of cement
Brick Maso	nry	
153	(a) Brick work in C.M. 1:4 with cut bricks	
	(22.9 cm x 11.2 cm x 7.00 cm)	72kg/m³
154	Brick work in C.M. 1:5 with wire bricks	
	(19 cm x 9 cm x 9 cm)	
154	(a) Brick work in cement mortar 1:5 with wire	
	cut bricks (22.9cm x 11.2 cm x 7.0 cm)	58kg/m³
158	Brick work in cement mortar 1:5 with country burnt	
450	brick (22.9 cm x 11.2 cm x 7 cm)	69 kg/m <sup>3</sup>
158	(a) Brick work in cement mortar 1:5 with country burnt	001 / 3
150	brick (19 cm x 9 cm x 9 cm)	69 kg/m <sup>3</sup>
159	Brick work in C.M. 1:6 with country burnt brick	501 -/3
450	(19 cm x 9 cm 9 cm)	58 kg/m <sup>3</sup>
159	(a) Brick work in C.M. 1:6 with country burnt	501 / 3
	brick (22.9 cm x 11.2 cm x 7.0 cm)	58 kg/m <sup>3</sup>
	(22.9 cm x 11.2 cm in C.M. 1.8)	43 kg/m <sup>3</sup>
Laterite Ma	sonry	
205	Laterite masonry in C.M. 1:4 cm x 24 cm x 14 cm)	58kg/m <sup>3</sup>
206	Laterite masonry in C.M. 1:5(44 cm x 24 cm x 14 cm)	46 kg/m <sup>3</sup>
Stone Maso Rubble Mas	•	
255	Cut stone work in steps 15 x 22 cm in C.M. 1:2	62 kg/m <sup>3</sup>
261	Coarsed rubble work split stone in cement mortar 1:2	101 kg/m <sup>3</sup>
264	Coarse rubble work II Sort in C.M. 1:4	79 Kg/m <sup>3</sup>
265	Coarse rubble - do- 1:5	63 kg/m <sup>3</sup>
272	Random rubble in cement mortar 1:4	108 kg/m <sup>3</sup>
273	Do. 1:5	86 kg/mn <sup>3</sup>
274	Do. 1:6	72 kg/m <sup>3</sup>
	Do. 1:8	54 kg/m <sup>3</sup>
Plastering		
506	Plastering with cement mortar 1:3 12 mm thick one coat	66 kg/10m <sup>2</sup>
510	Do.15 mm thick	72 kg/10m <sup>2</sup>
507	Do.1:4 12 mm thick one coat	54 kg/10m <sup>2</sup>
511	Do.15 mm thick	59 Kg/10m <sup>2</sup>
508	Plastering with Cement mortar 1:5 12 mm thick one coat	43 kg/10m <sup>2</sup>
509	Do do 1:6	36 kg/10m <sup>2</sup>
512	Do. 15 mm thick 1:5	48 kg/10m <sup>2</sup>
513	Do. 1:6 15 mm thick	40 kg/10m <sup>2</sup>
514	Cement flushing coat	22 kg/10m <sup>2</sup>
Cement Co		
110	CC 1:3:6 using 40 mm (nominal size) brocken stone	228 kg/m <sup>3</sup>
111	CC 1:4:8 using 40 mm (nominal size) broken stone	171 kg/m <sup>3</sup>

Ref.	Particulars	<b>S</b>	Quantity			
<u>Sched</u> 112		-:\ h	of cement 137 kg/m³			
122		CC 1:5:10 using 40 mm (nominal size) broken stone 1:2:4 using 20 mm (nominal size) broken stone				
122	(a) Cement concrete	, proteir storie	33 kg/10dm <sup>3</sup>			
	1:1 1/2:3 using 20 mm (nominal s	size) broken stone	4.32 kg/10dm <sup>3</sup>			
123	do. 1:3:6 do.		2.16 kg/10dm <sup>3</sup>			
124	do.1:4:8 do.		1.62 kg/10dm <sup>3</sup>			
	COVERING CAPACIT	Y OF PAINTS				
			Covering capacity			
l and n	rimor on wood		sq. m. per litre 9-11			
	rimer on wood rimer on metal		9-11 9-13			
	dercoating		10-12			
Gloss p			9-13			
Enamel			9-13			
Varnish	1st coat		11-13			
	2nd coat		13-18			
Water	paint and oil bound distemper cover appro	oximately	6-8 sq. m. per kg.			
	CO-EFFICIENT FOR MEASURE	MENTS OF PAINT	ING			
	Battened doors and windows		2.25			
	Panelled doors and windows		2.25			
-	Panelled and venetian doors		3.25			
	Panelled and with glazed top ron barred doors		3 1.50			
-	ron barred doors with batten and sheet		3.75			
••	Battened windows with iron ars		2.75			
	/enetian windows		3.50			
9. \	/enetian windows with iron bars		4			
10. \	enetian windows with glazed top and irc	n bars	4.50			
	enetian windows with iron bars and glaz	zed shutters	5			
	Glazed windows with iron bars		1.50			
13. C	Glazed shutters	MATION	1			
	GENERAL INFOR Maintenance of Buildings (G.O (Rt)	-	d 7-7-77]			
(a) i	for ordinary buildings constructed	3% of the capital	cost of the building			
` ,	before 1-4-1962.	•	0			
ii	For ordinary buildings constructed	2% of the capital	cost of the building			
	after 1-4-1962.					
(b) i.	For special buildings (like Hospitals,	4% of the capital	cost of the building			
	Rest Houses, Residential quarters etc.) constructed before 1-4-1962					
ii.	For special buildings	3% of the capital	cost of the building			
	constructed after 1-4-1962.	3 % Of the Capital	cost of the building			
(c) i.	For prestigious buildings	6% of the capital	cost of the building			
ι-,	constructed before 1-4-1962.	_, oophor				
ii.	For prestigious buildings	5% of the capital	cost of the building			

#### **HIGHWAYS**

#### CLASSIFICATION OF ROADS

- (a) Express ways: They shall be divided highways fit for all- weather use and should have atleast four lanes modern type surface with controlled access and grade separation at all road and rail crossings. The bridges shall be designed for the highest I.R.C. loading prescribed.
- (b) National and State Highways: They should be suitable for all- weather use and have modern type surface. Access to these roads shall be limited and where necessary parallel service roads shall be provided for local traffic. As regards culverts and bridges all existing structures shall be designed for the highest I.R.C.loading.
- (c ) Major District Roads: They shall be suitable for all weather use and have at least a metalled single lane carriage way. The type of surface will depend upon the needs of the traffic. All new bridges shall be designed for I.R.C. Class A loading.
- (d) Other District Roads: They shall be suitable for all weather use except at major river crossing where low level structures or ferries may be provided. The carriage way shall have a single lane width. The surface need be gravel or stabilised soil except where the considerations of climate and traffic necessitate a higher type of pavement. All bridges and culverts shall be designed for Class A loading.
- (e) Village Roads: These roads may have single lane carriage way with low cost surface of gravel or stabilised soil. They shall be provided with culverts at small streams, cause ways over minor river crossings and level structures or ferries at major river crossings. Village roads and other district roads are together known as rural roads.

### MINIMUM STANDARDS FOR ROADS IN KERALA (VIDE KSS, 1974)

SI No	Description	National Highways	State Highways	District Roads MD. Rs. & OD Rs.	Village Roads	Remarks
1	Land width or right of wa a) In open agricultural areas or built up areas	•	30m	15m	8 m	
	<ul><li>b) By-passes</li><li>c) Hilly tracts</li></ul>	60 m 22m	45 m			
2	Width of formation: a) In plains b) In hilly section: In hard rock for two lane Do. single lane Other than hard rock two lanes	12m 9 m 7 m 12 m	12 m 9 m 7 m 10 m	7 m	7 m	
	Do. single lane	7.5 m	7.5 m	7 m	4 m	
3a	Width of pavement in stra	ight reaches	i			
	Single lane Two lanes without kerbs Do. with kerbs	3.75 m 7.00 m 7.50m	3.75 m 7.00 m 7.50 m	3.75m 7.00 m 7.50 m	3 m	
3b	Extra widening of paveme rad. 150-300 m	nt at curves 0.3 m	for radii ab 0.3 m	ove 300 m		

	rad. 60-150 m below 60 m	0.6 m 0.9 m	0.6 m 0.9 m	0.3 m 0.6 m	0.6 m
4	Camber				
7	Earth or gravel Water bound macadam Black topped surface Cement concrete For shoulders and berms	1 in 25 1 in 33 1 in 50 1 in 72 1 in 33	1 in 33 1 in 50 1 in 72 1 in 33	1 in 33 1 in 50 1 in 72 1 in 33	1 in 33 1 in 50 1 in 72 1 in 25
5	Gradients in Plains				
J	Ruling Limiting Gardient In hills ruling limiting	1 in 30 1 in 20 1 in 20 1 in 15	1 in 30 1 in 20 1 in 20 1 in 15	1 in 30 1 in 15 1 in 15 1 in 12	1 in 20 1 in 15 1 in 15 1 in 12
6	Radius of Horizontal Cur	VAS			
Ü	Radius of Horizontal Cul		n plains		
	ruling min.	370 m	370 m	240 m	90 m
	absolute min.	250 m	250 m	150 m	45 m
		In roll	ing country	,	
	ruling min.	250 m	250 m		30 m
	absolute min.	155m	155m	100 m	40 m
			In hills		
	ruling min.	80 m	80 m	80 m	45 m
	absolute min.	50 m	50m	50 m	30 m
7	Super elevation design sp	peed for calc	ulating sup	er elevation	
	In rolling train in hilly country	80 km/h 50 km/h	80 km/h 50 km/h	65 km/h 40 km/h	35 km/h Super eln 25km/h

## **DESIGN SPEEDS ON RURAL HIGHWAYS**

Road classification	Ruling design speed in km/h for various terrains				
	Plain	Rolling	Mountainous	Steep	
National and State Highways	100	80	50	40	
Major District Roads	80	65	40	30	
Other District Roads	65	50	30	25	
Village Roads	50	40	25	25	

## TRANSITION LENGTH, SUPER-ELEVATION & WIDENING AT CURVES

	Plain/l	Rolling			Roll	ing		Hilly		Hilly		
Curve	80 KP	Н			65 k	(PH		50 KI	РΗ	40 K	(PH	
Radius	LS	е	W	LS	е	W	LS	е	w	LS	е	W
(m)	m	%	m	m	%	m	m	%	m	m	%	m
60	-	-	-	-	-	-	-	-	-	40	8.0	0.6
90	-	-		-	-	-	50	8.0	0.6	40	8.0	0.6
100	-	-	-	-	-	-	40	8.0*	0.6	30	7.0*	0.6

155	-	-	-	60	6.7	0.3	30	7.5*	0.3	30	4.7	0.3
170	-	-	-	60	6.7	0.3	30	6.6	0.3	20	4.1	0.3
200	-	-	-	50	6.7	0.3	20	5.6	0.3	-	-	-
250	100	6.7	0.3	50	6.7	0.3	20	4.6	0.3	-	-	-
300	100	6.7	-	80	6.7	0.3	40	6.2	0.3	-	-	-
350	100	6.7	-	60	6.7	-	40	5.3	-	-	-	-
370	100	6.7	-	60	6.7	-	30	5.0	-	-	-	-
400	100	6.7	-	60	6.7	-	30	5.0	-	-	-	-
500	90	6.7	-	50	5.6	-	30	3.7	-	-	-	-
600	80	6.7	-	40	4.7	-	-	-	-	-	-	-
700	70	6.7	-	30	4.0	-	-	-	-	-	-	-
800	60	5.6	-	30	3.5	-	-	-	-	-	-	-
900	50	5.0	-	30	3.1	-	-	-	-	-	-	-
1000	50	4.5	-	30	2.8	-	-	-	-	-	-	-
1200	40	3.8	-	30	2.3	-	-	-	-	-	-	-
1500	30	3.0	-	-	-	-	-	-	-	-	-	-
1800	30	2.5	-	-	-	-	-	-	-	-	-	-
2000	30	2.3	-	-	-	-	-	-	-	-	-	-

LS = Transition length in metres. e = Super - elevation per cent. w = Extra Width at curve in metre.

$$e = \frac{V^2}{225R}$$

V - Speed in kmph

R - Radius of curve in m

$$e+f = \frac{V^2}{127R}$$

Check with value of f <1.5 for maximum value of e and if necessary reduce speed

## RECOMMENDED PCU FACTORS FOR VARIOUS TYPES OF VEHICLES (IRC 64- 1990 and IRC 86-1983)

	•	•	
		PCU values	
SI.No	Vehicle type	Rural roads	Urban roads
Fast ve	ehicles		
1	Motor Cycle/ Scooter/Cycle	0.5	0.5
2	Passenger Car, Pick Up Van Or Auto Rickshaw Or Jeep	1.00	1.00
3	Truck or Bus	3.00	3.00
4	Cycle rickshaw	2.00	1.5
5	Hand cart	3.00	6.00
6	Horse- drawn vehicle	4.00	4.00
7	Bullock cart	8.00	8.00

<sup>\*</sup>Maximum allowable Super-elevation - 7%

CAPACITY OF FOOTPATHS (IRC 86-1983)						
No of persons per hour		Dogwired width of feetneth (m)				
All in one direction	In both direction	Required width of footpath (m)				
1200	800	1.5				
2400	1600	2.0				
3600	2400	2.5				
4800	3200	3.0				
6000	4000	4.0				

## **SIGHT DISTANCE ON RURAL HIGWAYS (IRC 66-1976)**

Speed kmph (m)	Safe stopping sight distance (m)	Safe overtaking sight distance (m)	Safe intermediate sight distance (m)	
40	45	165	90	
50	60	235	120	
60	80	300	160	
65	90	340	180	
80	120	470	240	
100	180	640	360	

## TYPES OF DESIGN VEHICLES AS PER IRC

- 1. Single unit truck
- 2. Semi- trailer
- 3. Truck- trailer combination

## STANDARDS OF DIMENSIONS FOR DESIGN VEHICLES

		Maximum overall len	gth (m)	
Maximum width (m)	Maximum height (m)	Single unit truck	Semi trailer	Truck- trailer
2.5	3.8 - 4.2 (Truck)	11.0	16.0	18.0
	4.75 (Double Decker bus)			

#### COMPONENT LAYERS OF THE PAVEMENT

**Sub Grade:** Sub grades shall be well compacted to utilise their full strength and to economise thereby on the overall thickness of pavement required. 95-100 percent of the standard Proctor density is to be ensured in the top 50 cm.of the sub grade. If the sub grade consists of bad clay or other unsuitable materials, the top 150mm. or other specified depth of sub grade shall be removed and the excavation filled with earth accepted for other portions of the road, levelled, shaped, watered and compacted.

**Sub base:** Where there is the possibility of the sub grade working into the base, a layer of soling stones or suitably designed admixture of soils may be laid. The thickness of the sub base shall be determined from the CBR values of the Sub grade; but should not be less than 10 cm.

**Base:** Base material shall be of good quality to stand the high stress concentration which develop. Immediately under the wearing surface. The minimum thickness recommended for base is 15 cms. even in minor roads. Water bound macadam is usually adopted as a basecourse material for our roads.

**Surfacing:** Thin surface dressings and open graded premix carpets would be sufficient for medium to heavy traffic. For very heavy traffic and at locations like bus -stops and round abouts dense asphaltic concrete in single or multiple courses is suggested.

# RECOMMENDED TYPE AND THICKNESS OF BITUMINOUS WEARING COURSES FOR FLEXIBLE PAVEMENTS UNDER DIFFERENT SITUATIONS (IRC 82-1982)

SL No	Type of base/ binder course	Type of bituminous wearing course	Annual rainfallLow (L) < 1500mm Medium (M)- 1500 to 3000mmHigh (H) > 3000mm	Design Traffic (msa)
	Water-bound	(i) 20 mm premix		< 10.0
	macadam	carpet (PC) with sand	L & M	< 10.0
	Wet mix macadam	(ii) 20 mm PC with	L, M & H	< 10.0
1	Crusher-run	seal coat		
	-macadam	liquid seal coat		
	Built-up spray	(iii) Mix seal surfacing	L, M & H	
	grout	(MSS) (20 mm)		
		Type A or B		
	Bituminous	(i) Semi-dense		
2	macadamBase/	bituminous concrete	L, M & H	< 10.0
	binder course	(25 mm)		10.0
		(ii) 20 mm PC with liquid seal coat	L, M & H	< 10.0
		(iii) MSS (20 mm)	L, M & H	< 10.0
		Type A or B		
		Bituminous concrete		
		(i) 25 mm	L, M & H	>5 < 10.0
3	Dense bituminous	Bituminous concrete		
	macadam	(ii) 40 mm	L, M & H	≥ 10
		Bituminous concrete (iii) 50 mm	L, M & H	≥ 100

## CRITERIA FOR THE SELECTION OF GRADE OF BITUMEN FOR BITUMINOUS COURSES (IRC 82- 1982)

SL. No	Climate	Traffic	Bituminous course	Grade of bit	umen to be used	
				Penetration	Viscocity	
1	Hot	Any	BM, BPM, BUSG	60 / 70	VG-20	
2	Moderate/ cold	Any	BM, BPM, BUSG	80 / 100	VG-10	
3	Any	Heavy loads, express ways, urban roads	DBM, SDBC, BC	60 / 70	VG-20	
4	Hot/ moderate	Any	Premix carpet	50 -60	VG-30	
5	Cold	Any	Premix carpet	80 / 100	VG-10	
6	Hot/ moderate	Any	Mastic asphalt	$15 \pm 5$	-	
7	Cold	Any	Mastic asphalt	30 / 40	VG-40	
BM	- Bitumino	ıs Macadam				
BPM	- Bituminou	is Penetration Maca	dam			
BUSG	- Built up Spray Grout					
DBM	- Dense Bituminous Macadam					
SDBC	- Semi-Dens Bituminous Concrete					
ВС	- Bituminou	is Concrete				

## **DESIRABLE PROPERTIES OF PAVING BITUMEN**

SI.	Equivalent grade	30 / 40	40 / 50	60 / 70	80 / 100	180 / 2	00	Methodof test
	IS grade	S 35	S 45	S 65	S 90	S 200		
i	Specific gravity at 2 (min)	7° C	0.99	0.99	0.99	0.98	0.97	IS 1202 - 1958
ii	Water, % by weight Flash point (°C min)	. ,	0.2	0.2	0.2	0.2	0.2	IS 1211 - 1958
iii	Pensky Martin's close	ed type)	175	175	175	175	175	IS 1209 - 1958
iv	Softening point (°C)		50 - 65	45 - 60	40 - 55	35 - 50	35 - 50	IS 1205 - 1958
V	Penetration at 25° C 5sec in 1/100 cm	100g	30 - 40	40 - 50	60 - 70	80 - 100	175 - 225	IS 1203 - 1958
νi	Ductility at 27 ° C in cm (min)		50	75	75	75	-	IS 1208 - 1958

## DESIRABLE PROPERTIES OF STONE AGGREGATOR FOR BITUMINOUS CONSTRUCTION

S. No	Test		Valu	е
1	Los Angeles abrasion value Or Aggregate impact value			35% 30%
2	Flakiness index	(i) Surface dressing and premix carpet (ii) Bituminous macadam		30%
		and asphaltic concrete		35%
3	Stripping value		Max	25%
4	Water absorption		Max	2%
5	Soundness: loss with sodium sulphate 5 cycles (in case of slag only)	: -	Max	12%
6	Unit weight / bulk density (in case of	slag only)	Min 1	1120 kg/ m <sup>3</sup>

## SPECIFICATION FOR TEMPERATURE IN BITUMINOUS WORKS

Type of construction	Temperature a Mixing bitume	Temperature of mix at laying	
	Bitumen	Mix	
Tack coat surface dressing 80 / 100 penetration	163 – 177	Dry	-
Penetration macadam 80 / 100 penetration	163 – 177	Dry	-
Penetration macadam 30 / 40 penetration	177 – 190	Dry	-
BUSG 80 / 100 penetration	163 – 177	Dry	-
Open graded mixes 80 / 100 penetration	150 – 165	125 – 150	110 – 135
Open graded mixes 60 / 70 penetration	165 – 180	125 – 150	110 – 135
Dense – semi dense mixes 80 /100 penetration	165 – 180	150 – 177	155 – 163
Dense – semi dense mixes 60 / 70 penetration	165 – 177	150 – 177	155 – 163
Dense – semi dense mixes 30 / 40 penetration	175 – 190	150 – 177	155 – 163

4.16 REQUIREMENTS OF MATERIALS FOR PAVEMENT CONSTRUCTION

Ref. No	Specification	60 mm graded	36 mm	12 mm	6 mm	Red earth	Bitumen
2.1	WBM sub base	1m <sup>3</sup> /10m <sup>2</sup>				0.2m <sup>3</sup> /10m <sup>2</sup>	
2.2	WBM base		1m <sup>3</sup> /10m <sup>2</sup>			0.15m <sup>3</sup> /10m <sup>2</sup>	
2.3	Re metalling WBM base course		0.5m <sup>3</sup> /10m <sup>2</sup>			0.12m <sup>3</sup> /10m <sup>2</sup>	
3.1.1	Levelling undulation less than 20 mm						
	with 12 mm metal			Max. 20%			48 kg/m³
3.1.2	3.1.2 Levelling between 20mm and 40mm						
	with 12mm metal	ı	,	1m³		1	$48 \text{ kg/m}^3$
3.1.3	3.1.3 Levelling between 40mm and 150mm						
	with 36mm metal	ı	1m³		,	1	$20 \text{ kg/m}^3$
3.2	20mm pre mixed chipping carpet with						
	heavy seal coat over WBM		,	0.27m³/10m²	0.09m <sup>3</sup> /10m <sup>2</sup>	,	29.1 kg/10m <sup>2</sup>
3.2	20mm pre mixed chipping carpet with						
	heavy seal coat over BT surface		,	$0.27  \text{m}^3 / 10  \text{m}^2$	0.09m <sup>3</sup> /10m <sup>2</sup>	,	26.6 kg/10m <sup>2</sup>
3.3	Semi grouting including heavy pre mix seal coat		0.6m³/10m²	0.18m³/10m²	0.09m³/10m²	,	26.14kg/10m²
3.6.1	3.6.1 Filling up pot holes on black topped surface with 36mm metal	•	1m³				27.5 kg/m³
3.6.2	3.6.2 Filling up pot holes on black topped surface with 12mm metal	1	1	1m³	,	1	60 kg/m³

# REQUIREMENT OF MATERIALS FOR REPAIRING PAVEMENT DEFECTS (IRC 82- 1982)

(A) Liquid seal

Penetration grade bitumen – 9.8 kg/ 10 m<sup>2</sup> Cover aggregate 0.09 m<sup>3</sup> per 10 m<sup>2</sup> (nominal size 6.3 mm)

(B) Fog seal

Emulsion is diluted with an equal amount of water and sprayed at the rate of 0.5 - 1.0 litre /  $m^2$  (of diluted material)

(C) Slurry seal

### Gradation of aggregates

Sieve size	% by weight passing the sieve
4.75 mm	100
2.36 mm	80 - 100
1.18 mm	50 - 90
300 μ	15 - 50
150 $\mu$	10 – 25
75 µ	3 – 10
mulcified hitumen	10 20% by weight of aga

Emulsified bitumen - 18 - 20% by weight of aggregates Water - 10 - 12% by weight of aggregates

(D) Sand bituminous premix - patching

Sand - 0.06  $m^3$  /10  $m^2$  (passing 1.70 mm IS sieve and retained on 180  $\mu$  sieve) Binder (RC - 3/ MC- 3) - 6.8 kg/ 10  $m^2$ 

(E) Premix open-graded patching (for a thickness of 20 mm)

(i) Coarse aggregate (12.5 mm size) - 0.18 m $^3$  / 10 m $^2$  (ii) Coarse aggregate (10 mm size) - 0.09 m $^3$  / 10 m $^2$  (iii) Penetration grade bitumen Track coat - 7.5 kg/ 10 m $^2$  Premix - 14.6 kg/ 10 m $^2$ 

(F) Premix dense graded patching

Coarse aggregate, fine aggregate and filler shall be mixed in suitable proportions to obtain a final composition satisfying any of the two gradings set forth below:-

Sieve	% by weight passing the sieve		
	Grading I	Grading II	
20 mm	-	100	
12.5 mm	100	80 - 100	
10 mm	80 - 100	70 - 90	
4.75 mm	55 - 75	50 - 70	
2.36 mm	35 - 50	35 - 50	
600 µ	18 – 29	18 - 29	
300 µ	13 – 23	13 - 23	
150 $\mu$	8 - 16	8 - 16	
75 µ	4 - 10	4 - 10	

Quantity of binder

5 to 7.5% by weight of total mix

- (G) Penetration patching (for 50 mm compacted thickness )
  - (i) Coarse aggregate -0.60 m<sup>3</sup> / 10 m<sup>2</sup>
  - (ii) Key aggregate (iii) Penetration grade bitumen  $0.15 \text{ m}^3 / 10 \text{ m}^2$

7.5 kg/ 10 m<sup>2</sup> 50 kg/ 10 m<sup>2</sup> Tack coat -Grouting

# **Gradation of Aggregates**

Sieve size	% by weight passing the sieve
50 mm	100
25 mm	35 - 70
12.5 mm	0 - 15
2.36 mm	0 - 5
20 mm	100
12.5 mm	35 - 70
4.75 mm	0 - 15
2.36 mm	0 - 5

# SPECIFICATION FOR 2cm THICK BITUMEN CARPET (IRC 14-1977)

# (A) Requirements for aggregates

	· · · ·		
Νo	Property	Value	Method of test
1	Abrasion value, using Los Angeles machine OrAggregate impact value	Max 35% Max 30%	IS.: 2386 (Part IV)-
2	Flakiness index	Max 30%	IS.: 2386 (Part I)
3	Stripping value	Max 25%	IS.: 6241
4	Water absorption (except in case of slags)	Max 2%	IS.: 2386 (Part III)
5	Soundness: Loss with Sodium Sulphate- 5 cycles (in case of slag only)	Max 12%	IS.: 2386 (Part V)
6	Unit weight or bulk density (in case of slag only)	Min 1120 kg p	er m³ IS.: 2386 (Part III)
	(B) Quantities of aggre	gates required	
	(I) For carp	et	
	Coarse aggregates- 13.2 mm size; passing IS 22.4 sh, retained on IS 11.2 mm square mesh	4 mm square	Per 10 m <sup>2</sup> of road surface 0.18 m <sup>3</sup>
	Coarse aggregates- 11.2 mm size; passing IS 13.2 sh, retained on IS 5.6 mm square mesh	2 mm square	$0.09\ m^3 \ 0.27\ m^3$
	(II) For seal of	coat	D 40 3 6 1 6
(a)	Low rainfall areas (under 150 cm per year)Medium	coarse sand	Per 10 m <sup>2</sup> of road surface
(fine	eness modulus of more than 2.5) or fine grit passin 1.70mm & retained on IS Sieve No. 180 microns		0.06 m <sup>3</sup>
- 6.	High rain fall areas (over 150 cm per year)Coarse 7 mm size; passing IS Sieve 11.2mm Square mesl 2.8 mm mesh		0.09 m <sup>3</sup>

# (c) Quantity of binders required per 10 m<sup>2</sup> of road surface

(I) For tack coat

7.3 to 9.8 kg
4.9 to 7.3 kg
6.8 kg
9.8 kg

# **GRADES OF BITUMEN (IS 73: 2006)**

Bitumens shall be classified into four types, based on viscosity, as

- a) VG 10
- b) VG 20
- c) VG 30
- d) VG 40

The various grades of bitumen shall conform to the requirements as shown in Table

Table Requirements for Paving Bitumen (Clause 6.2)

SI No:	Ch	Characteristics				ades	Methods of Test, Ref to IS No:	
			VG 10	VG 20	VG 30	VG 40		
(1)	(2)		(3)	(4)	(5)	(6)	(7)	
1		solute viscosity at deg Celsius, Poises, Min	800	1600	2400	3200	IS 1206 (Part 2)	
2		ematic viscosity at 135 deg elsius, cSt, Min	250	300	350	400	IS 1206 (Part 3)	
3		sh point (Cleveland open cup g celsius, Min	)),	220	220	220	220 IS 1209	
4		ubility in trichloroethylene, crcent, Min	99.0	99.0	99.0	99.0	IS 1216	
5		netration at 25 deg Celsius, Og, 5 s, 0.1 mm	80-100	60-80	50-70	40-60	IS 1203	
6		tening point(R&B), g Celsius, Min	40	45	47	50	IS 1205	
7		sts on residue from thin film en tests/RTFOT						
	1	Viscosity ratio at 60 deg Celsius, max	4.0	4.0	4.0	4.0	IS 1206 (Part 2)	
	2	Ductility at 25 deg Celsius, cm, Min, after thin-film oven test	75	50	40	25	IS 1208	

Source: IS 73: 2006

## **HYDRAULICS**

1. Discharge through Rectangular orifice.

$$Q = CdLh$$

where h = Height of opening, L = length of orifice

H = Total head from centre of opening to surface

Cd = Coefficient of discharge (Minimum value 0.6 - increases with value

of 
$$\frac{h}{2H}$$

2. Discharge through circular orifice.

$$Q = CdA\sqrt{2gH}$$

where A = area of opening

Note:- Value of Cd can be 0.97 for bell mouth orifice

3. Submerged orifice.

$$Q = Cdh\sqrt{2g(H - H_1)}$$

 $H-H_{\scriptscriptstyle 1}=$  the difference in head of water

4. Discharge over a sharp crested weir or Notch.

$$Q = \frac{2}{3} CdL \sqrt{2gH^{\frac{3}{2}}} = 1.841 H^{\frac{3}{2}}$$

where h = head causing flowCd = 0.623(average value)

4(a) When velocity of approach is also taken into account

$$Q = \frac{2}{3} CdL \sqrt{2gh} + \left[ H + \frac{v_1^2}{2g} + \frac{v_2^2}{2g} \right]^{\frac{3}{2}}$$

5. Discharge over a V Notch weir

$$Q = \frac{8}{15}Cd\sqrt{2g}Tan\frac{\phi}{2}H^{\frac{3}{2}}$$

Where  $\phi$  = angle of notch, Cd = 0.6

6. Discharge over Trapezoidal weir

$$Q = \frac{2}{3}CdL\sqrt{2g}H^{\frac{3}{2}} + \frac{8}{15}Cd\sqrt{2g}Tan\phi an\phi H^{\frac{5}{2}}$$

 $\Phi$  = Angle between sides of weir and vertical, Cd = 0.6

7. Discharge over Submerged weir

$$Q = \frac{2}{3}Cd_1L\sqrt{2g}(H_1 - H_2)^{\frac{3}{2}} + Cd_2LH_2\sqrt{2g(H_1 - H_2)}$$

 $Cd_1=0.577$  (approx.),  $Cd_2=0.80$  (approx.) H = head over weir on the upstream side

H<sub>2</sub>=head over weir on downstream side

$$Q = CdL\sqrt{2g} \sqrt{Hh^2 - h^3}$$
For maximum discharge  $h = H^{\frac{2}{3}}$ 

$$Q = 1.7 Cd_1 H^{\frac{2}{3}}$$

$$\frac{2}{1704 \text{ Hz}^3}$$

When crest is very broad  $Q = 38L\sqrt{2gh} \frac{7}{2}$ 

Discharge over an Ogees crested weir 9.

$$O = 2.2LH^{\frac{3}{2}}$$

8.

10. Flow through open channel(Mannings formulae)

Velocity (m/sec) 
$$V = \frac{R^{\frac{2}{3}} S^{\frac{1}{2}}}{n}$$

R = Hydraulic mean depth= A/P

- where  $A = \text{area of cross section in } m^2$ P = wetted perimeter in metres

  - S =slope of the channel bed n = rugosity coefficient (used values given below)
  - Earth with weeds = 0.035 concrete 0.017
  - Clean earth 0.025 concrete for aqueducts

- Pointed rubble masonry 0.222 flumes etc.
- Flow through Pipes a. Friction loss  $h_1 = \frac{4 f l v^2}{2 g d}$ 11.

Where  $h_1$ = head loss in friction in metres

- I =length of pipe in metres v = velocity of flow in m/sec
- d = diameter of pipe in metres

f = friction coefficient

For new pipes 
$$f = \left[1 + \frac{1}{40d}\right]$$
 (approximate)

For old pipes 
$$f = \left[1 + \frac{1}{40d}\right]$$
 (approximate)

b. Loss of head due to sudden enlargement

$$=\frac{(v_1-v_2)^2}{2q}$$

Where  $v_1$  = velocity in smaller side

$$v_2$$
 = velocity in larger side

c. Loss due to sudden contraction

$$=0.5\frac{v^2}{2g}$$

d. Loss of head at entrance

=0.5 
$$\frac{v^2}{2a}$$
 (Coefficient 0.1 for bell mouth entrance)

e. Loss of head due to obstruction

$$= \left(\frac{A}{0.66(A-a)}\right)^2 \frac{v^2}{2q}$$

A = area of pipe

a = area of obstruction

### **HYDROLOGY**

### Flood estimation

1. Dicken's formulae

 $Q = CA^{\frac{3}{4}}$  where *C* depending on catchment and is equal to 11.45 for areas with annual rainfall between 610mm and 1270mm. (22 for Western Ghats)

2. Ryves formulae

$$Q = CA^{\frac{2}{3}}$$

Q = flood discharge in cum/sec

A = area of catchment in sq. km

C = Coefficient, Varying from 6.76 to 40.6 depending on the nature of catchment, intensity of rainfall etc

3. A Rational formulae

Q = CIA cum/sec

I = Intensity of rainfall in m/sec

A = area of catchment in sq.m

C = Run off factor for the area considere

(C for Bare soil 0.15 to 0.30, spare turf 0.10 to 0.25, for dense wooded turf 0.05 to 0.15)

4. Modified Mayer's formulae

$$Q = 177\sqrt{\frac{P}{A}}$$
 in cumes

Where P has a value of unity for stream that has the greatest flood flow of the area. For any other stream, P is the fraction on that the flood flow of that stream is, of the maximum given above. For different streams values of P vary from 0.002 to 1.0.

### **CANALS**

1. Average duty for canal systems

 $\Delta = 60$  acres/cusec = 850 ha/ cumec

2. Critical velocity  $Vo = 0.546 \ D^{0.64}$ 

Where D = depth of flow in meters

Critical velocity ratio V/Vo varies from about 1.1 to 1.2 for coarse materials head reaches to 0.8 to 0.9 for fine sand in tail ends.

3. Allowable velocity in canals

Sandy soil 0.3 to 0.6 m/sec
Ordinary soil 0.6 to 0.9 m/sec
Hard soil, murum 0.9 to 1.06 m/sec
Gravel, disintegrated rock 1.5 m/sec
Concrete lined 2.5 m/sec

 Bed width to depth ration (B/D) usually varies from 1 to 6 for discharges varying from 0.5 to 60 cumecs

5. Side slopes - Recommended values are

	Type of soil	Cutting H.V	Embankment H.V
	Loose sand and average sandy soil	1.5:1 to 2:1	2:1 to 3:1
	Sandy loam, black cotton and similar soils, gravelly soil	1:1 to 1:5:1	1:5:1
	Murum, hard soil	0.75:1 to 1:5:1	1:5:1
	Rock	0.25:1 to 0.5:1	
6.	Free board  Main Canal  For other canals with discharges monor Do. Less than 10 cumecs  Minimum free board for lining	re than 10 cumecs	1.00 m 0.75 m 0.5 m 0.3 m
7.	Top width of bank Inspection bank The other bank		3.2 to 4.2 m 1.5 to 2.0 m

3. Concrete lining For capacity upto 25 cumecs. In situ concrete lining 1:4:7 with graded metal (60% 40 mm size and 40 % 20 mm sizes) with simultaneous plastering 9 mm thick with C M 1:3 mixed with crude oil 5% by weight can be used. For capacity above 25 cumecs concrete M 100 (1:3:6) can be used.

Precast slabs of convenient size; say 60 cm x 50 cm x 5 m can also be used. Thickness of lining can be 7.5 cm for slopes flatter than 1:1. For 1:1 side slope, thickness can be 10 cm at the tow reducing to 7.5 cm at top.

Expansion joints, reverse filter with drains, and pressure relief holes have to be provided when canal is lined with concrete.

- 9. Loss of head in fluming for aqueducts etc.
  - 1. Loss of head at inlet transition  $=\frac{0.2(v_2^2-v_1^2)}{2g}$
  - 2. Loss of head outlet transition =  $\frac{0.3(v_2^2 v_1^2)}{2g}$

V<sub>1</sub> = velocity in canal

 $V_2$  = velocity in flumed section

10. Canal losses

Conveyance losses -12% to 20% of discharge

Field losses - about 10%

Conveyance losses usually adopted for design of canals in 8 cumecs per million square feet

# THE CONDITION FOR A RECTANGULAR CHANNEL AND TRAPEZOIDAL CHANNEL MOST ECONOMICAL

## 1) Rectangular Channel

- i) The depth of the flow is equal to half the base width. (y=b/2)
- ii) Hydraulic radius is equal to half the depth of flow (R=y/2)

### 2) Trapezoidal Section

- i) Half of the top width = One of the sloping sides  $((b+2ny)/2=y''(n^2+1))$
- ii) Hydraulic radius, R = y/2
- iii) A semicircle drawn from O with radius equal to depth of flow will touch the three isdes of the trapezoidal channel

### **PUMPS**

### 1. Classification Of Pumps

On the basis of transfer of mechanical energy the pumps can be broadly classified as follows 1. Rotodynamic pumps

- 1) Radial Flow pumps
  - 2) Axial Flow pumps
  - 3) Mixed Flow pumps
- 2. Positive displacement pumps

In rotodynamic pumps, increase in energy level is due to a combination of centrifugal energy, pressure energy and kinetic energy.

- The energy transfer, in a radial flow pump, occurs mainly when the flow is in its radial path.
- In an axial flow pump, the energy transfer occurs when the flow is in its axial direction.
- The energy transfer in a mixed flow pump takes place when the flow comprises radial as well
  as axial components.

# Classification Of Centrifugal Pumps

On the basis of

1.	Type of casing
a)	Volute pumps
b)	Turbine pump
2.	Working head
a)	Low lift
b)	Medium lift
c)	High lift
3.	Liquid handled
a)	Closed impeller
b)	Semi-open impeller
c)	Open impeller
4)	Number of impeller per shaft
a)	Single stage centrifugal pump
c)	Multi-stage centrifugal pump
5)	Number of entrances to the impeller
a)	Single entry or Single suction pump
c)	Double entry or Double suction pump
6)	Relative direction of flow through the impeller
a)	Radial flow pump

## **Classification Of Reciprocating Pumps**

According to

c)

1. The water being in contact with piston

Axial flow pump

Mixed flow pump

- a) Single acting
- Double acting b)
  - **Number of cylinders**

Single cylinder

- b) Double cylinder
- c) Triple cylinder
- d) **Duplex Double acting**
- e) Quintuplex
- 2 For Centrifugal Pump, The Work Done (W.d) Per Unit Weight Of Liquid

The work done per unit weight of liquid  $=\frac{1}{q}(Vw_2u_2-V_{W_1u_1})$ 

# 3 Efficiencies Of A Centrifugal Pump

i) Manometric efficiency 
$$(\eta_{mano}) = \frac{gH_{mano}}{W_2 u_2}$$

ii) Volumetric efficiency 
$$(\eta_V) = \frac{Q}{Q+q}$$

ii) Mechanical efficiency 
$$(\eta_m) = \frac{w(Q+q)(V_{W_2}u_2/g)}{P}$$

iv) Overall efficiency 
$$(\eta_0) = \frac{wQH_{mano}}{P}$$

4. Specific Speed Of A Centrifugal Pump

Specific Speed, 
$$N_S = \frac{N\sqrt{Q}}{(H_{mano})^{\frac{3}{4}}}$$

5. Minimum Speed For Starting A Centrifugal Pump

Minimum speed for starting a centrifugal pump, 
$$N = \frac{120\eta_{mano}V_{W_2}D_2}{\pi(D_2^2 - D_1^2)}$$

6. Discharge Through A Reciprocating Pump/ Sec

Discharge through a reciprocating pump/ sec,  $Q = AL \frac{N}{60}$  (single acting)

Discharge through a reciprocating pump/ sec,  $Q = [(\frac{\pi}{4}DL^2 + \frac{\pi}{4}(D^2 - d^2)]L\frac{N}{60}]$  (Double acting)

7. Work Done By A Reciprocating Pump/Sec

Work done /sec = 
$$\frac{wALN}{60} (h_S + h_d)$$
 (single acting)

Work done/sec = 
$$\frac{2wALN}{60}(h_S + h_d)$$
 (Double acting)

8. Slip Of A Pump

% Slip = 
$$\frac{Q_{th} - Q_{act}}{Q_{th}} \times 100 = (1 - C_d) \times 100$$

### SOIL AND FOUNDATION

### **DEPTH OF FOUNDATION**

Depth of foundation 
$$h = \frac{P}{W} \left[ \frac{1 - \sin \theta}{1 + \sin \theta} \right]^2$$

Where P = Safe permissible pressure on base.

W = Unit weight of the soil

For chimneys and towers  $3/4^{th}$  of safe load on the soil can be taken and the depth 'h' increased by 1/3.

Pile foundation

Safe load on piles:  $P = \frac{16.7wh}{s + 2.54}$ 

P = Safe loads on pile in kg.

w = Weight of monkey in kg.

h = Height of fall in meters

s = Average penetration in cm/blow

(Measured as the average of the last 5 to 10 blows under a drop hammer)

### SOIL EXPLORATION - BASIC INFORMATION

# A. Guidelines for initial planning of borehole spacing

Nature of a Project	Bore Spacing	
	m	f
One Story Building	25-30	75-100
Multi Storied Building	15-25	50-75
Highways	250-300	750-1000
Earth dams	25-50	75-150
Residential Subdivision Planning	60-100	200-300

## B. Guidelines for selection of borehole depth

Test borings should be extended to firm soil layers suitable for supporting foundation. As a rough estimate for depth of boreholes (in the absence of suitable firm layer of rock/soil) following equations can be used.

Type of Building Depth of Borehole

Light steel or narrow concrete  $D_b = 3 \ S^{0.7}, \ S - No \ of \ Stories$  Heavy Steel or Wide concrete Buildings  $D_b = 6 \ S^{0.7}, \ S - No \ of \ Stories$ 

Soil Exploration Report

The soil exploration report should contain the following information:

- 1. Scope of investigation
- General description of the proposed structure for which the exploration has been conducted
- 3. Geologic conditions of the site
- 4. Drainage facilities at the site
- 5. Details of boring

- 6. Description of subsoil conditions as determined from soil and rock samples collected
- 7. Groundwater tables as observed from boreholes
- 8. Details of foundation, recommendations and alternatives
- 9. Any anticipated construction problems
- 10. Limitations of investigation

In addition following graphical presentations should also be included.

- Site location map
- 2. Location of borings with respect to the proposed structure
- 3. Boring logs
- 4. Laboratory test results
- 5. Other special presentations

# MAXIMUM SAFE BEARING CAPACITY (FROM IS 1904 - 1961)

SI	No Types of Rocks and Soils	Maximum Safe Bearing Capacity (tonnes/m²)
1	Rock head with out laminations and defect, (eg. Granite)	330
2	Laminate rocks in ground condition (eg. Sandstone and limestone)	165
3	Residual deposits of shattered and broken bed rock, hard shale, cemented material	90
4	Soft rock	45
5	Gravel or sand and gravel offering high resistance to penetration when excavated by tools	45
6	Course sand, compact and dry (Ground water level is at a depth not less than the width of the foundation below the base of the foundation)	45
7	Medium sand, compact and dry	45
8	Fine sand, silt (dry lumps easily pulverized by the fingers)	15
9	Loose gravel or sand-gravel mixture; Loose course to medium sand, $\mbox{dry}$	25
	Fine sand, loose and dry	10
	Soft shale, hard or stiff clay in deep bed, dry,	45
	Medium clay, readily indented with a thumb nail	25
13	Moist clay and sand clay mixture which can be indented with strong thumb pressure	15
11	Soft clay indented with moderate thumb pressure	10
	Very soft clay which can be penetrated several inches with the thumb	5
16	Fills or made-up ground	No generalized valuesof safe bearing pressure can be given for these types of soils. In such cases adequate site investigation shall be carried out and expert advice shall be sought

# **CLASSIFICATION AND BASIC FIELD IDENTIFICATION TESTS**

General Characteristics (Is 1498: 1970)

Soil group	Strength in natural state	Strength when wet and remoulded	Permeability	Dry bulk density g/cc
Gravels or gravel sand mixtures, little or no fine	Very low		Previous	1.84 to 2.00
Gravels or gravel sand mixtures with clady binder	Medium to high	Slightly plastic	Semi-previous to previous	2.08 t0 2.29
Slity gravel or gravel-sand-silt mixtures	None to slight	Finer fraction plastic	Semi-previous to impervious	1.92 to 2.16
Clayey sands or sand - clay mixtures	Slight to medium	Medium to high plasticity	Impervious	1.68 to 2.00
Silt and very fine sand, clayey fine sand with low plasticity	None to slight	Slight plastic but not cohesive	Semi-pervious to impervious	1.52 to 1.92
Inorganic clays of medium plasticity	Medium	Medium plasticity	Impervious	1.28 to 1.60
Inroganic clays of high plasticity	High	High plasticity	Impervious	1.20 to 1.68
Clay and silt with high organic content	Slight to high	Slight to high plasticity	Impervious	1.04 to 1.60

# **BASIC FIELD IDENTIFICATION TESTS (IS 1498: 1970)**

Soil Groups	Visual Exmination	Dry Strength	Wet and Manipulated Strength	Thread Test
Gravels or Gravel-sand mixtures, little or no fine	Hard, smooth maximum size- 50 mm, well rounded, containing 1/3 sand	Very low	Non plastic	Not possible to roll
Gravels or gravel-sand mixtures with clay binder	Hard pit gravel containg 1/3 sand clay binder	Medium	Slightly lastic	Possible to roll
Silty gravel or gravel-sand-silt mixtures	Gravel about 70% Maximum size 60mm- Moderately silty	None to slight	Fines practically non plastic	Threads less than 6mm not possible
Clayey sand or Silty gravel or mixtures	About 50-60% sand with clay binders	Medium to slight	Fines moderately to highly plastic	Possible to roll the thread, grity and coarse when broken dry
Silty sand or sand-silt mixtures	Sand very fine-large protion of silt about 10% gravel and 20 mm size	None to slight	Practically non-plastic	Threads less than 6mm - not possible to roll
Silt and very fine sand clayey fine sand with low plasticity	Predominantly silt withtraces of clay and excess fine sand	None to slight	Practically non-plastic	Possible to roll the thread 6mm with high moisture, coarse texture
Inorganic clays of medium plasticity	Fines 10-20% slightly silty	Medium to high	Very plastic	Possible to roll thread, smooth feel when broken dry
Inorganic clays of high plasticity	High percentage of clay, sand and silt not more than 10-15%	Very high	Very plastic	Fine textured thread, high strength when broken dry
Clay and silt with high organic content	Clay and silt Organic High odour of decayed matter, very plastic, no coarse material	Medium to high	Moderately to very plastic	Possible to roll thread, fine texture

# **ENVIRONMENTAL ENGG. AND WATER QUALITY**

# RECOMMENDED CAPACITIES AND SIZES OF SEPTIC TANKS (For Hostels and Boarding Schools)

No. of Users	Length (L)	Breadth (B)	Liquid dep stated interva withdrawal in	l of sludge	stated interv	oacities for al of sludge I in months	Distance of the partition wall from the inlet end
			Once in 12 months or or less	Once in 24 months or less	Once in 12 months or less	Once in 24 months or less	
	m	m	m	m	m³	m³	m
50	5.0	1.6	1.3	1.4	10.4	11.2	3.3
100	5.7	2.1	1.4	1.7	16.8	20.4	3.8
150	7.7	2.4	1.4	1.7	25.8	31.9	5.2
200	8.9	2.7	1.4	1.7	33.6	41.0	6.0
300	10.7	3.3	1.4	1.7	49.5	50.0	7.2

### STANDARDS FOR SANITARY ARRANGEMENTS (REF: NATIONAL BUILDING CODE)

(i)	Office	Buildings	

Wash basins

Urinals

Water Closet	For males	For females

1 for every 25 persons 1 for every 15 persons

or part thereof

Urinals Nil upto 6 persons

1 for 7-20 persons 2 for 21-45 persons 3 for 46-70 persons 4 for 71-100 persons

1 for every 25 persons

or part thereof

(ii) Hospitals: For males and females

Water Closet 1 for every 8 beds or part thereof.

2 upto 30 beds add 1 for every

additional 30 beds.

(iii) Theatres: For males

Water Closets 1 for every 100, above 400,

add 1 for every 250

Urinals 1 for every 50

Wash basins 1 for every 200

(iv) School:

Water Closets 1 for every 4 pupils or part thereof

1 for every 40 pupils or

part thereof

Wash basins 1 for every 40 pupils or

part thereof.

For females

2 for every 100, above 400,

add 1 for every 100

1 for every 20

1 for every 25 pupils or

part thereof

1 for every 40 pupils or

part thereof.

### **DESIGN OF DRAINAGE SYSTEM**

- (1) Allow for a flow of liquid waste from the buildings at the rate of 0.03 m<sup>3</sup>/min/100 persons.
- (ii) The minimum velocity in drain pipes shall be 0.75m/sec. The drain pipes shall be half full at peak flow. Velocity shall not exceed 2.4 m/sec.
- (iii) Pipe diameter shall not be less than 100 mm.
- (iv) Gradients for various pipe sizes and discharges are as follows:-

Velocity	Pipe dia	gradient
0.75 m/s	100	1 in 35
0.75 m/s	150	1 in 65
0.75 m/s	230	1 in 120
0.75 m/s	300	1 in 200

### QUALITY OF WATER FOR CONSTRUCTION WORKS (IS 456:2000 cl: 5.4)

SI. No	Parameters	Maximum permissible limit	Tested as per
1	Acidity	50 mg/L	IS 3025 Part 22
2	Total alkalinity	250 mg/L	IS 3025 Part 23
	Organic solids	200 mg/L	IS 3025 Part 18
	Inorganic solids	3000 mg/L	IS 3025 Part 18
	Sulphates (as SO <sub>3</sub> )	400 mg/L	IS 3025 Part 24
3	Solids	2000 mg/L (for concrete not containing embedded steel)	
	Chlorides (as CI)		IS 3025 Part 32
	, ,	500 mg/L (for reinforced cement concrete)	
	Suspended matter	2000 mg/L	IS 3025 Part 17

Note: Mixing or curing of concrete with sea water is not recommended because of the presence of harmful salts in sea water.

Water found satisfactory for mixing is also suitable for curing of concrete. However water used for curing should not produce any objectionable stain or unsighty deposits on the concrete surface. The presence of tannic acid or iron compounds is objectionable.

# PHYSICAL AND CHEMICAL STANDARDS OF DRINKING WATER (Ref. IS 10500: 1991)

SI. No	Characteristics	Requirement (desirable limit)	Permissible limit in the absence of alternative source	Methods of test (ref to IS)
1	Turbidity (Units J. D. U. Scale)	5	10	3025 (Part 10):1984
2	Colour (Units Platinum Cobalt Scale)	5	25	3025 (Part 4):1983

3	Taste and odour	Unobjectionable	Unobjectionable	3025 (Part 5) : 1983 3025 (Part 7&8) : 1984
4	PH	6.5 to 8.5	No relaxation	3025 (Part 25):1984
5	Total dissolved			
	solids (mg/l)	500	2000	3025 (Part 16):1984
6	Total hardness (mg/l)	300	600	3025 (Part 21):1983
7	Chlorides (as Mg) (mg/l)	250	1000	3025 (Part 32):1984
8	Sulphates (as SO <sub>4</sub> )	200	400	3025 (Part 24):1986
9	Fluorides (as F) (mg/l)	1.0	1.5	
10	Nitrates (as NO <sub>3</sub> ) (mg/l)	45	100	3025 (Part 34):1988
11	Calcium (as Ca) (mg/l)	75	200	3025 (Part 40):1991
12	Magnesium (as Mg) (mg/l) [If there are 250 mg/l of Sulphates, Mg content can			
	be increased to a maximum	≤30	150	3025 (Part
40):1	1991 of 125 mg/l with the reduction of at the rate of 1 unit per every 2.5 units of Sulphates]	ı		
13	Iron (as Fe) (mg/l)	0.3	1.0	32 of 3025:1964
14	Manganese (as Mn) (mg/l)	0.1	0.3	35 of 3025:1964
15	Copper (as Cu) (mg/l)	0.05	1.5	36 of 3025:1964
16	Aluminium (as Al) (mg/l)	0.03	0.2	31 of 3025:1964
17	Alkalinity (mg/l)	200	600	13 of 3025:1964
18	Residual Chlorine (mg/l)	0.2		3025 (Part 26):1986
19	Zinc (as Zn) (mg/l)	5	15	39 of 3025:1964
20	Phenolic compounds			
	(as Phenol) (mg/l)	0.001	0.002	54 of 3025:1964
21	Anionic detergents (mg/l) (MBAS)	0.2	1.0	Methylene-blue
22	Mineral oil (mg/l)	0.01	0.03	extraction method Gas hromatographic
	Tavila mat	- wi-ala		method
	Toxic mate			
23	Arsenic (as As) (mg/l)	0.05	No relaxation	3025 (Part 37):1988
24	Cadmium (as Cd) (mg/l)	0.01	No relaxation	Atomic absorption spectrop otometric method may be used
25	Chromium (as Hexavalent Cr) (mg/l)	0.05	No relaxation	38 of 3025:1964

26	Cyanides (as CN) (mg/l)	0.05	No relaxation	3025 (Part 27):1986
27	Lead (as Pb) (mg/l)	0.05	No relaxation	Atomic absorption spectrophoto metric method may be used
28	Selenium (as Se) (mg/l)	0.01	No relaxation	28 of 3025:1964
29	Mercury (total as Hg) (mg/l)	0.001	No relaxation	Mercury ion analyzer
30	Polynuclear aromatic	-	-	-
	hydrocarbons (PAH)			
	Radio	activity		
31	Gross Alpha activity (Bq/I)	-	0.1	
32	Gross Beta activity (Bq/I)	-	1.0	

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# DESIGN CRITERIA FOR WATER SUPPLY SCHEMES (Source: CPHEEO Manual on Water Supply and Treatment, GOI 1999)

### Design period for the components in water supply schemes

SI no.	Items	Design period in years
1	Storage by dams	50
2	Infiltration works	30
3	Pumping: I. pump house(civil works) II. electric motors and pumps	30 15
4	Water treatment units	15
5	Pipe connection to several treatment units and other small appurtenances	30
6	Raw water and clear water conveying mains	30
7	Clear water reservoirs at the head works, balancing tanks and service reservoirs (overhead or ground level)	15
8	Distribution system	30

# RECOMMENDED PER CAPITA WATER SUPPLY LEVELS FOR DESIGN OF SCHEMES

SI no. towns /cities		Classification of Recommended maximum water supply levels
1	Towns provided with piped water supply but without sewerage system	70
2	3 ,	70
2	Cities provided with piped water supply where sewerage system is existing /contemplated	135
3	Metropolitan and mega cities provided with piped water supply where sewerage system is existing/contemplated	150

# RECOMMENDED WATER SUPPLY LEVELS FOR INSTITUTIONS

SI no	Institutions	Litres per head per day
1	Hospital(including laundry) a)no. of beds exceeding 100	450 (per bed)
	b) no. of beds not exceeding 100	340(per bed)
2	Hotels	180(per bed)
3	Hostels	135
4	Nurses' homes and medical quarters	135
5	Boarding schools/colleges	135
6	Restaurants	70 (per seat)
7	Airports and seaports	70
8	Junction stations and intermediate stations where mail or express stoppage ( both railways and bus stations) is provided	70
9	Terminal stations	45
10	Intermediate stations (excluding mail and express stops)	45 (could be reduced to 25 where bathing facilities are not provided)
11	Day schools /colleges	45
12	Offices	45
13	Factories	45 ( could be reduced to 30 where no bathrooms are provided)
14	Cinema,concert halls and theatre	15

# RECOMMENDED WATER REQUIREMENTS FOR INDUSTRIES

Industry	Unit of production	Water requirements in Kilolitres per unit
Automobile	Vehicle	40
Distillery	(Kilolitre alcohol)	122-170
Fertiliser	Tonne	80-200
Leather	100 Kg(tanned)	4
Paper	Tonne	200-400
Special quality paper	Tonne	400-1000
Straw board	Tonne	75-100
Petroleum Refinery	Tonne(crude)	1-2
Steel	Tonne	200-250
Sugar Textile	Tonne (cane crushed) 100 Kg (goods)	1-2 8-14

# RECOMMENDED WATER REQUIREMENTS FOR DOMESTIC & NON-DOMESTIC NEEDS

Description	Amount of water(lpcd
Description	Amount of water(lpc

1.For communities with population upto 20,000

a) Water supply through stand post	40 (min.)
b) Water supply through house supply connect	ion. 70 to 100
2.For communities with population 20,000 to	100,000 100 to 150
3For communities with population above 100,	000 150 to 200

#### FLOW REQUIREMENT FOR PLUMBING FIXTURES

Plumbing fixture	Flow required	Flow required (litres per minute)			
	Good	Reasonable			
Kitchen Tap	10	7			
Bath tap (cold)	25	15			
W .C flushing cistern	10	7			

### DIAMETER OF SERVICE PIPES FOR NUMBER OF OCCUPANTS

No.of occupants	4	8	24	60
Dia.of service pipe (mm)	12.5	20	25	30

### **HEAD LOSS DUE TO FRICTION**

Darcy - Weisbach Formula

i) Head loss due to friction, 
$$h_f = \frac{fL}{2gD} \left( \frac{16Q^2}{\pi^2 D^2} \right)$$

Where,  $h_f = head loss due to friction$ 

L = length of the pipe

Q = flow through the pipe

g = acceleration due to gravity

D = internal diameter of the pipe

(ii) Velocity of flow, Hazen - Williams Formula  $V = 0.354 \ CD^{2.63} S^{0.54}$ 

Where, V = mean velocity of flow

C = coefficient of roughness of pipe

D = diameter of the pipe

S = hydraulic gradient

## LOCATION AND REQUIREMENTS OF WELLS (Ref. National Building Code, 2005)

The well shall be located:

(a) not less than 15 m from any ash pit, refuse pit, earth closet or privy and shall be located on a site upward from the earth closet or privy.

- (b) Not less than 18 m from any cess pit soak way or borehole latrine
- (c) That contamination by the movement of subsoil or other water is unlikely

### The well shall

- a) have a minimum internal diameter of not less than 1 metre
- (b) be constructed to a height not less than 1 m above the surrounding ground level to form a parapet or kerb to and to prevent surface water from flowing into a well
- (c) be of sound and permanent construction throughout

# LOCATION AND REQUIREMENTS OF SEPTIC TANKS (Ref. National Building Code, 2005)

- (a) Septic tanks shall have a minimum width of 75 cm, minimum depth of 1 m below the water level and a minimum liquid capacity of 1m³. The length of the tank s shall be 2 to 4 times the width
- (b) Septic tanks may be constructed of brickwork, stone masonry, concrete or other suitable materials as approved by the authority.
- (c) The minimum nominal diameter of the pipe shall be 100 mm
- (d) The gradient of land drains, under drainage as well as the bottom of the dispersion trenches and soak ways shall be between 1:300 and 1:400.
- (e) Every septic tank shall be provided with ventilating pipe of at least 50 mm diameter.

### Colouring of Building Plans

SI.No	Item	Site Plan			В	uilding F	Plan
		White Plan	Blue Print	Ammonia Print	White Plan	Blue Print	Ammonia Print
1	Plot lines	Thick black	Thick black	Thick black	Thick black	Thick black	Thick black
2	Existing street	Green	Green	Green	-	-	-
3	Future street, if any	Green dotted	Green dotted	Green dotted	-	-	-
4	Permissible building lines	Thick dotted black	Thick dotted black	Thick dotted black	-	-	-
5	Open spaces	No colour	No colour	No colour	No colour	No colour	No colour
6	Existing work	Black(outline)	White	Blue	Black	White	Blue
7	Drainage& Sewerage work	Red dotted	Red dotted	Red dotted	Red dotted	Red dotted	Red dotted
8	Water Supply work	Black dotted thin	Black dottedthin	Black dottedthin	Black dotted thin	Black dotted thin	Black dotted thin

# **RIVERS OF KERALA**

# (A) West Flowing

	Name of			nent area (m²		le Water rce Mm³
	river	Length km.	ln Kerala	Outside Kerala	in Kerala	Outside Kerala
1.	Manjeswar	16	90			
2.	Uppala	50	76	174	106	273
3.	Shiriya	67	290	297	358	615
4.	Mogral	34	132			
5.	Chandragiri	105	570	836	1218	1911
6.	Chittari	25	145		100	
7.	Nileswar	46	190			
8.	Kariangode	64	429	132	937	301
9.	Kavvaiyi	31	143			
10.	Peruvamba	51	300		603	
11.	Ramapuram	19	52			
12.	Kuppam	82	469	70	786	238
13.	Valapattanam	110	132	546	1828	1115
14.	Anjarakandy	48	412		503	
15.	Tellicherry	28	132		122	
16.	Mahe	54	394			
17.	Kuttiyadi	74	583		1015	
18.	Korapuzha	46	624			
19.	Kallai	22	96			
20.	Chaliyar	169	2535	388	2616	544
21.	Kadalundi	130	1122			
22.	Tirur	48	117		60	
23.	Bharathapuzha	209	4400	1786	3349	797
24.	Keecheri	51	401			
25.	Puzhakkal	29	234		345	

	Name of			nent area m2		ole Water rce Mm3
	river	Length km.	In Kerala	Outside Kerala	in Kerala	Outside Kerala
26.	Karuvannur	48	1054		963	
27.	Chalakudy	130	1404	300	1539	494
28.	Periyar	244	5284	114	8004	226
29.	Muvattupuzha	121	1554		1812	
30.	Meenachil	78	1272		1110	
31.	Manimala	90	847		1108	
32.	Pamba	176	2235		3164	
33.	Achencoil	128	1484		1249	
34.	Pallickal	42	220			
35.	Kallada	121	1699		1368	
36.	Ithikara	56	642		429	
37.	Ayoor	17	66			
38.	Vamanapuram	88	607		889	
39.	Mamom	27	114			
40.	Karamana	68	702		462	
41.	Neyyar	56	497		229	
(B)	East Flowing					
1.	Kabani	1920		153		
2.	Bhavani	562		36		
3.	Pambar	384		25		

# **IRRIGATION PROJECTS IN KERALA**

# A. Completed Irrigation Projects

SI		Estimated Cost	Ayacut	in ha
No.	Name of Project	(Rs. lakhs)	Net	Gross
1.	Walayar	132	3878	6476
2.	Malampuzha	580	20733	42330
3.	Cheerakuzhi	91	1620	3240
4.	a) Meenkara			
	<ul><li>b) Chulliyar</li></ul>	220	5465	10930
5.	Pothundy	138	5465	10930
6.	Mangalam	106	3440	6880
7.	Vazhani	108	3565	7130
8.	Peechi	235	17555	28080
9.	Chalakudy	279	19690	39380
10.	Neyyar	461	15380	23470
11.	Pazhassi	7736	11525	23050
12.	Kuttiadi	4485	14569	31161
13.	Kanhirapuzha	1052	14569	31161
14.	Chitturpuzha	2063	15700	31400
15.	Periyar Valley	6305	32800	85600
16.	Pamba	6595	21135	49456
17.	Kallada	45780	61630	92800
18.	Chimony	-	13000	25000

# B. Projects under execution

SI.			ed Cost lakhs)	Ayacut in Ha	
No.	Name of Project	Appvd.	Revised	Net	Gross
<u>A.</u>	Major Irrigation proje	cts			
1.	Idamalayar		7561	14393	43190
2.	Muvattupuzha	4808	8925	17737	34730
3.	Karappara - Kuriarkutty	-	6016	15132	32980
4.	Chaliyar	-	37800	73235	108035
5.	Kakkadavu	-	9885	13986	41760
B.	Medium Irrigation Pro	ojects			
1.	Karapuzha	760	4014	4650	9300
2.	Attappady	-	5839	4347	8378
3.	Banasurasagar				
	(Kuttiadi Augmentation)	-	1798	2800	3300
4.	Vamanapuram	3640	-	8803	18014
5.	Regulator-cum-Bridge at Char	mravattom -	2451	3106	9659
6.	Meenachil	-	4956	9960	14510

### **DIMENSIONS OF PLAYGROUNDS**

#### 1. Football Field

Length - 90 m to 120 m. Breadth - 45 m to 90 m. For International matches the length shall be 100 to 110m and breadth 64 to 75m. Goal posts are 7.32 m apart (inside measurement) and cross bar (lower edge) 2.4 m from ground.

### 2. Hockey Field

Length - 100 yds/91.44 m. Breadth - 60 yds/54.86 m. Goal posts are 4 yds/3.66 m apart and cross bar 7 ft/2.13 m from ground (inside measurements).

#### 3. Basketball Court

Length - 28 m. Width - 15 m. Radius of centre circle - 1.8 m. Size of back board - 1.8 m x 1.2 m Diameter of basket - 0.45 m (inside). Height of the basket from floor - 3.05 m.

### 4. Volleyball Court

Length - 18 m. Width - 9 m. Net shall be 1.0 m wide and 9.5 m long. The height of the net (top edge) from the ground shall be 2.43 m for men and 2.24 m for women.

#### 5. Lawn Tennis Court

Length - 78 ft/23.77 m. Breadth - 36 ft/10/97 m (27 ft/8.23 m for singles). Height of net at the centre - 3 ft /0.915 m.

### 6. Badminton (Ball) court

Length - 80 ft/24.38 m. Breadth - 40 ft/12.19 m. Height of net (top edge) from ground - 6 ft/1.83 mat centre and 6 ft lin/ 1.855 m at posts.

### 7. Mini Basketball Court

Length - 26 m. Breadth - 14 m. Radius of centre circle - 1.8 m Size of backboqard - 1.20 x 0.9 m Diameter of basket - 0.45 m (inside). Height of basket from floor 2.60 m.

### 8. Handball Court

Length - 40 m. Width - 20 m. Goal posts are 3.0 m apart and 2.0 m high.

### 9. Badminton (Shuttle) Court

Length - 44 ft/13.40 m. Breadth - 20 ft/6. 10 m. Height of net (top edge) from ground - 5 ft/1.524 ..... m at centre..... and 5 ft 1 inch/1,55 m....at posts.

### 10. Table Tennis

Size of table - 9 ft/2.74 m x 5 ft/1.52 m. Height of playing surface from floor - 2.5 ft/0.76 m. Height of net from playing surface - 15.25 cm. Diameter of - ball- 38 mm. Weight of ball - 2.5 gm.

### 11. Cricket

Ball - weight 5 1/2 to 5 3/4 Oz. Circumference 8 1/2 to 9 Inch

Bat - Max width 4 1/4 inch. Max Length 38 inch.

Wickets - 22 yards from stump to stump. Pitch - 5 feet on each side, Top of stumps 28 inch from ground.

Ground - Minimum 60 yards from centre of pitch

# RL ON RAILTOP @ RAILWAY STATIONS

Stations	MSL m	Stations	MSL m
Kasargode	9.50	Changanecherry	6.36
Kanhangad	2.46	Thiruvalla	54.75
Kannur	11.58	Chengannur	8.93
Thalassery	2.13	Mavelikkara	8.63
Mahe/Mayyazhi	4.57	Kayamkulam	7.12
Badagara	3.05	Karunagappalli	8.75
Calicut	4.04	Quilon Jn.	26.175
Tirur	4.39	Paravur	8.46
Kuttippuram	13.41	Varkala	49.53
Shornur	28.51	Chirayinkil	7.32
Palakkad Town	81.26	Kazhakkootam	8.24
Palakkad Jn.	77.68	Kochuveli	4.680
Wadakkancheri	37.49	Pettah	8.290
Thrissur	3.05	Tvm Central	6.74
Angamali	14.04	Nemam	23.716
Alwaye	11.28	Balaramapuram	31.970
Ernakulam Town	2.44	Neyyattinkara	14.374
Ernakulam Jn.	1.20	Dhanuvachapuram	38.271
Cochin Harbour Terminal	1.54	Parassala	40.724
Tripunithura	1.83	Nagarcovil	10.600
Mulanthuruthi	5.00	Kanyakumari	30.335
Piravom Road	7.56	Cherthala	4.26
Ettumannoor	21.56	Alappuzha	3.65
Kottayam	4.94		

Visit www.keralapwd.gov.in for shortest routes between places

DISTANCE BY RAIL	_ (In K.N	1.)		DISTANCE BY ROA	D
THIRUVANANTHAP	JRAM-	Madurai	268	NH 47 (State Boun	daries
MANGALORE		SHORNUR JNN	ILAMBU	RWalayar	
Thiruvananthapurar	m 0	Shornur	0	(182/200) to Parasa	ıla
Kollam in.	65	Vallapuzha	10	(599/1000)	
Sasthamcottah	85	Angadipuram	28	THIRUVANANTHAP	JRAM-
Karunagapply	92	Melattur	41	PALAKKAD	
Kayamkulam jn.	106	Vaniyambalam	56	Thiruvananthapuran	
Mavelikkara	114	Nilambur	66	Attingal	33
Chengannur	126			Kollam Kayamkulam	71 109
Thiruvalla	135	THIRUVANANTHAPU	JRAM-	Haripad	122
Changanassery	143	KANYAKUMARI	•	Alappuzha	157
Kottayam	161	Thiruvananthapurar		Cherthala	178
Vaikom Road	186	Nemom	8	Ernakulam	219
Ernakulam in.	221	Balaramapuram	14	Aluva	240
Aluva	241	Neyyattinkara	18	Angamali Chalakudy	251 268
Chalakkudy	265	Parassala	30	Thrissur	297
Irinjalakkuda	272	Nagercoil	71	Alathur	340
Thirussur	296	Kanyakumari	87	Palakkad	365
Wadakkanchery	312	ERNAKULAM		THIRUVANANTHAP	IR A M _
Shornur in.	328	ALAPPUZHA-			
Tirur	373	KAYAMKULAM		CAPE COMORIN	. 0
Kozhikode	414	Ernakulam	0	Thiruvananthapuran Balaramapuram	n 0 13
Quailandy	439	Arur	13	Neyyattinkara	20
Vadakara	461	Cherthala	34	Amaravila	23
Mahe	474	Alappuzha	57	Parassala	30
Thalassery	483	Haripad	87	Kaliyikkavila	32
Kannur	504	Kayamkulam	100	Nagercoil	70
Payyannur	537	THRISSUR - GURUVAYI	JR	Cape Comorin	
Kanhangad	566	Thrissur	0	NH 17: THALAPPA	ΝI
Kasargod	589	Guruvayur	30	EDAPPALLI	ועו
Manjeswar	618			Thalappadi	
Mangalore	635	THIRUVANANTHAPU	RAM-	(State Boundary)	
KOLLAM Jn MA	DIID A I	COIMBATORE		Kasargode	33
Kollam JII MA	DUKAI ()	Thiruvananthapurar		Kannur	140
Kottarakara	24	Shornur	328	Thalassery	160
Punalur	44	Ottappalam	341	Vadakara	182
Thenmala	66	Palakkad	373	Kozhikode	226
Aryankavu	94	Walayar Coimabatore	398 427	Kuttipuram	301
Aivalikavu	94	Comadatore	42/	Ponnani	320

Pudu Ponnani	325	NH 47 A - Link Road -		
Chavakkad 344		Wellingdon Island to		
Kodungallur 390		Kochi By - pass-5.92 km.		
Parur	419	NH 208 Kollam-Aryankavu		
Edappally Jn	438/827	-Thirumangalam81.280km		
Joins with NH 47		NH 212 Kozhikode Mysore		
NH 49 - Cochi		•		
Madurai - 167.2	2 Km ()	- Kollegel 117/6 (Muthanga)		

NH 213 Kozhikode Palakkad 15.656 to 140/956 **NH 220** Kollam- Kottayam-Kumaly- Theni 25.900 to 215/485 (Kumaly)

# STATE HIGHWAYS UNDER KERALA P.W.D. AS ON 01.04.2009

SI. N o	Road N o		tal ength
1.	SH-1	Main Central Road	240.600
2.	SH-2	Thiruvananthapuram-Nedumangad-Chullimanoor-Palode-Madathara-Kulthupuzha	73.300
3.	SH-3	Nedumangad-Aryanad-Kallikad-Vallichal-Vellarada- Shorlacode Highway	37.500
4.		Kollam Shenkotta Road (N.H,208)	
5.	SH-5	Kayamkulam-Adoor-Pathanapuram Highway	42.500
6.	SH-6	Kayamkulam-Mavelikkara-Thiruvalla Highway	30.800
7.	SH-7	Thiruvalla-Eraviperoor-Kumbanad-Kozhencherry-Kalanjoor- Pathanamthitta-Kumbazha Highway	32.800
8.	SH-8	Punalur-Pathanapuram-Konni-Ranni-placherry-Elankulam- Pravithanam-Thodupuzha-Muvattupuzha Highway	153.600
9	SH-9	Kottayam-Karukachal-Mallappally-Kozhencherry Highway	44.400
10.	SH-10	Mavelikkara-Chenganoor-Aranmula-Kozhencherry Highway	28.700
11.	SH-11	Alappuzha-Pallathuruthy-Nedumudi-Kidangara-Changanasse Highway	ry 24.200
12.	SH-12	Ambalapuzha-Thakazhi-Edathuva-Thalavadi-Thiruvalla Highway	27.200
13	SH-13	Kottayam-Pampadi-Ponkunnam-Kanjirappally-Mundaka Perumedu-Vandiperiyar-Kumily Highway (N.H.220)	yam-
14	SH-14	Erattupetta-Theekoyi-Vellikulam-Vagaman-Perumedu Highwa	y 48.300
15	SH-15	Ettumanoor-Kadathuruthy-Thalayolaparambu-Vaikkam- Tripunithura-Ernakulam Highway	57.300
16	SH-16	Aluva-Perumbavoor-Kothamangalam-Neriyamangalam-Pallivasal-Munnar Highway (N.H. 49)	55.00
17	SH-17	Munnar-Thalyar-Marayoor-Udumalpet road	59.100
18	SH-18	Munnar-Mattupetti-Kundala-Ellupodi-Top station Highway	32.100
19	SH-19	Munnar-Santhanpara-Udumpanchola-Vandanmedu-Valaveed Kumily Highway	u- 106.00
20	SH-20	Kothamangalam-Muvattupuzha-Puthenkurisu-Tripunith Highway (N.H. 49)	ura
21	SH-21	Chalakudy-Thampamoozhi-Anamala Highway	86.00
22	SH-22	Kodungallur-Irinjalakuda-Karuvathoor-Thrissur-Vadakancher Shornur Highway	y 70.500

23	SH-23	Shornur-Pattambi-Perithalmanna Highway	39.300
24	SH-24	Kozhikode Palakkad (N.H-213)	
25	SH-25	Thathamangalam-Chittoor-Nattukal Highway	14.200
26	SH-26	Nattukal-Velamthavalam Highway	11.600
27	SH-27	Palakkad-Koduvayur-Thathamangalam-Meenakshipuram Highway	35.600
28	SH-28	Kozhikode-Ferook-Kondotty-Manjeri-Nilambur-Gudallur Highway (N.H - 213)	103.600
29	SH-29	Kozhikode-Kummangalam-Thamaracherry-Vythri-Gudallur highway (N.H - 212)	37.00
30	SH-30	Thalassery-Koothuparambu-Mattanoor-Iritty Coorg Highway	55.128
31	SH-31	Kalladka-Bathiyadukka-Cherkala road	28.800
32	SH-32	Ettumanoor-Kummanoor-Kadapattoor-Pala-Barananganam- Erattupetta-Poonjar road	37.900
33	SH-33	Thodupuzha-Muttam-Arakulam-Paramada-Painavu- Narakanam-Kattapana-Puliyanmala road	92.100
34	SH-34	Koilandy-Ullerri-Thamarassery-Mukkom-Areakode- Edavanna road	44.00
35		Choondayil Wayanad Mysore Frontier Road (N.H - 212)	
36	SH-36	Thaliparamba-Sreekantapuram-Perumanna-Iritty Road	46.470
37	SH-37	Adoor-Manakala-Kadampanad-Chakuvally-Sasthamkotta road	18.200
38	SH-38	Puthiyangadi-Ulleri-Perambra-Kuttiyadi-Nadapuram-Irikkur- Panoor-Koothuparamba-Chova byepass	101.490
39	SH-39	Perumbilavu-Pattambi-Perinthalmanna-Pattikadu- Karuvarakundu Kalikavu-Nilambur road	107.110
40	SH-40	Alappuzha-Thaneermukkam-Thalayolaparambu- Koothattukulam-Kozhippally-Vazhithala-Erattathodu- Nediyachala-Thodupuzha-West Kodikulam-Kodikulam- Vannapuram-Chelachuvadu-Murikkacherry-Melachinnar- Nedumkandam-Thannimoodu-Thukkupalam- Kampammedu-Santhanpara-Bodimettu-Madurai road	114.820
41	SH-41	Ernakulam-Thekkady Road (Edappally Kizhakkambalam Pattimattam-Muvattupuzha-Arakkapuzha-Pandappally-Parakkadavu-Thodupuzha-Moolamattam-Pullikkanam-Wagmar Parappu-Merikulam Anavilasam, Kumily-Thekkady	150.000
42	SH-42	Kumarakom-Vechoor-Kallara-Ayamkutty-Appanchira- Kaduthuruthy-Nilaroor-Elanji-Karinpana-Palakuzha-Marika- Vazhithla-Illucherry-Alamcode-Pannimattam- Kulamavu-Pathinaramkadam-Thoppramkudy- Chempagapara-Cumbammettu-Cumbam road	108.000
43	SH-43	Muvattupuzha-Perumkandam-West Kodikulam- East Kodikulam-Pariyaram-Kottakavila-Paramada-Idukki- Mariyapuram-Uppukandam-Kattapana-Kambanmedu- Kambam-Theni road	89.300
44	SH-44	Sabarimala-Pamba-Chalakayam-Plapally-Thulappally-Erumeli-kanjirapally-Erattupetta-Melukavu-Thonnikallu-Muttam-	126.010

			066.000
		<u> </u>	662.748
76	SH-76	Kuranchery Veloor road	12.838
75	SH-75	Thrissur Kanjani Vadanappally road	16.120
74	SH-74	Pazhayannur Road from Vazhakode to Alathur	33.690
73	SH-73	Valancheri-Angadipuram-Wandoor-Vadapuram-Nilambur road	51.410
72	SH-72	Malappuram-Parappanangadi road	29.000
71	SH-71	Tirur-Malappuram-Manjeri road	39.000
70	SH-70	Karuvarakundu-Melattoor road	9.820
69	SH-69	Thrissur-Kuttippuram road	52.650
68	SH-68	Kappad-Thusharagiri-Adivaram road	68.110
67	SH-67	Mannarakulanji-Pampa road	56.750
66	SH-66	Alappuzha-Arthunkal-Chellanam Thoppumpady road	51.720
65	SH-65	Parapanangadi-Areacode road	40.450
64	SH-64	Varkala-Parippally-Madathara road	44.697
63	SH-63	Vypeen Palluppuram road	25.500
62	SH-62	Guruvayoor-Althara-Ponnani road	28.600
61	SH-61	Potta-Alloor-Tholuthana-Chanthakunnu-Dana-Eduthuruthy- Kaddathuruthy-Moonupeedika road	27.665
60	SH-60	Angadipuram-Pulamanthol-Elamkulam-Pariyapuram-Cherukara road	7.610
59	SH-59	Hill Highway starting from Kadukkara-Neyyardam and ending at Sugayhakatta-Nandarappadavu (Kasargode Dist.)	960.000
58	SH-58	Vadakkancherry-Nenmara-Kollamcode-Muthalavala- Govindapuram- Pollachi road	39.00
57	SH-57	Kasargode-Pallikkara-Kanhangad road	29.500
56	SH-56	Kanhangad-Mavumkal-Kolichal-Panathoor road	44.100
55	SH-55	Peruvannamoozhi-Padinjerethara-Kalpetta Cherkala-Kodiyerri-Jalsoor road	39.140
54	SH-54	Thiruvazhiyod-Cherplacherry Perinthalmanna road Kozhikode-Puthiyangadi-Ullyeri-Perambra-Poozhithodu-	58.500 99.00
53	SH-53	Palakkad-Mundoor-Koorana-Kadambipuram-Mangalamkunnu-	
52	SH-52	Palakkad-Kozhinjampara-Gopalapuram-Pollachi road	29.900
51	SH-51	Wadakkancherry road Kodakara-Aloor-Mala-Krishnanpetta-Anapuzha-Kodungallur road	
50	S⊓-50	Cnavakkad-Ovukkaipaily-Mammiyoor-Kattapadi-Arekad- Kunnamangalam-Erumapetti-Mangadi-Ottupara-	31.520
49 50	SH-49 SH-50	Guruvayoor-Chovvallurpadi-Kunammuchi-Choondal road Chavakkad-Ovukkalpally-Mammiyoor-Kattapadi-Arekad-	7.280
48 49	SH-48 SH-49	Ayoor-Anchal-Punalur Road	19.650
47	SH-47	Attingal-Venjaramoodu-vembayam-Nedumangad road	25.000
46	SH-46	Kilimanoor-Nagaroor-Alamcode	9.800
45	SH-45	Thiruvananthapuram-Peroorkada-Nedumangad-Chullimanoor-Ponmudi road	
45	011.45	Thodupuzha-Neriyamangalam-Kallarkutty-Pallivasal- Munnar Top staion-Kodaikkanal road	07.000

### GOVERNMENT OF KERALA Abstract

Public Works Department - Revision of Public Works Department Code and Manual - Modification to the existing rules and procedures - orders issued.

### PUBLIC WORKS (H) DEPARTMENT

GO(P) No.84/97/PW&T

Dated, Thiruvananthapuram 19-8-1997

Read :- 1) GO(MS) No.74/91/PW&T dated 15-10-1991
2) Letter No.PL(2) 59340/90 dated 24-1-1994 from the Chief Engineer, Admn (PWD), Thiruvananthapuram
3) GO(P) No.558/97/Fin dated 3-6-1997

### **ORDER**

In the G.O. read as first paper above, Government constituted a committee under the chairmanship of the then Commissioner & Secretary, PWD for revising the PWD Code and Manual. The draft Code submitted by the Committee consists of a number of changes in the existing rules and regulations. Government have examined the proposals in detail and orders enhancing the financial powers of the various officers of the PWD have been issued in the GO read as third paper above.

As part of the revision of the PWD Code and Manual, Government are pleased to issue the following further orders in supersession of the orders issued in the matter.

### i) Supply of departmental materials :-

Cement and steel will not be supplied departmentally in respect of works in which the estimated cost exceeds the T.S. powers of the Superintending Engineer. The contractors will purchase the same and complete the work. They will also establish laboratory facilities for testing quality of the materials at their cost.

For works costing upto the T.S. powers of the Superintending Engineer, cement and steel will be supplied departmentally. If cement, steel and bitumen are not available in the departmental stores, the contractor will be bound by agreement to purchase the same from open market and complete the works as per the time schedule fixed. In such cases, he will be paid the market price of the materials and conveyance at market rates to the nearest available source as fixed by the Executive Engineer (Buildings) of the concerned District as prescribed in the G.O. read as 3rd paper above. It will be the responsibility of the Officer arranging the work to ensure the quality of the materials used by the contractors . Testing wherever necessary will be done by the contractor at his cost. This will be included in the agreement to be executed between the Department and the contractor.

### ii) Extension of time of completion of work and fine :-

(a) To take care of any departmental delays or delay occuring due to

unexpected technical problems faced during execution of a work, a grace period of 20% of the original time of completion will be allowed, if found necessary, to complete the work. The Officer granting grace period will record in detail the reasons for allowing the extension in detail. The grace period will not be granted if the extension is necessitated due to the default on the part of the contractor.

b) For extension of time of completion beyond the grace period, fine will be imposed at the following rates:-

Period of extension First three months Rate of fine
1% of the PAC subject to a
minimum of Rs 300/- and
maximum of Rs 15,000/-

For every three months beyond the first three months

2% of the PAC subject to a minimum of Rs 600/- and maximum of Rs 30.000/-

For extension of time of completion for part of the said period, proportionate amount of fine will be levied.

### (iii) Payment of bonus for completing the work in time :-

Bonus will be paid to the contractor at the rate of 1% of the T.S. amount subject to a maximum of Rs 3 lakhs for completion of works within the prescribed time limit in respect of works which exceed T.S. powers of the Superintending Engineer (ie. above 55 lakhs).

### iv) Termination of contract :-

The present system of risk and cost termination will continue.

### v) Bank Guarantee :-

For pre-qualification works, bank guarantee at the rate of 10% will be insisted at the time of executing agreement.

## vi) Limited Tender :-

Limited Tender System will be adopted in works related to V.V.I.P. visits. In this system, tender documents/quotations will be sold only to contractors in a selected panel maintained by the Executive Engineer. The panel is subject to revision once in every two years based on the performance certificate of the contractors. The powers under "waiving of tender calls" will be permissible in this system also.

### vii) Responsibility for safe custody of materials at work site/stores :-

The responsibility for safe custody of materials at work site and during transit will be vested with the contractor. The concerned overseer in charge of the work will verify the stock and initiate action if shortage in stock is noticed. Other inspecting officers will also verify the stock during inspection.

### viii) Payment of works bills :-

The Officer competent to make payment for work will be authorised to effect payment upto a maximum of 75% of the bill amount without detailed scrutiny in his office, if the Officer himself is satisfied of the genuineness of the bills subject to the

condition that if any excess payment is noticed, the Officer who authorised the payment will be held responsible. A certificate to this effect will be recorded in the bill by the Officer who passes the bill, before making the payment.

### ix) Works under untied fund :-

The District Panchayat Wing of the Department will be authorised to undertake works under untied funds, following the rules prescribed for the scheme. The provision of the PWD Code will not be applicable for the works taken up by the Department under untied funds.

### x) Nominee System:-

The Officers of the various wings of the PWD will be authorised to undertake execution of works under different schemes on nominee system if such a request is made by the agency sanctioning funds of the work or such a system is prescribed for a particular scheme. The PWD Code will not be applicable in such cases.

### xi) Procedure for accepting negotiated quotations :-

The Officers of PWD will be authorised to take up works within their powers for waiving of tender calls allowing tender excess upto a maximum limit of the estimated cost based on market rates fixed by the Executive Engineer of the concerned District. While exercising this power, the concerned Officer will report to the immediate superior Officer. The Chief Engineer will have powers to sanction tender excess in this case without reporting to Government.

### xii) Postal Tender :-

Postal Tender System will be adopted for all works exceeding the T.S powers of the Executive Engineer.

### xiii) Approval of Designs :-

Detailed investigation of sub soil and approval of designs will be completed before preparing the estimates of all works. A certificate to this effect will be recorded in the estimate by the concerned Officer.

### xiv) Centage charges :-

The centage charges to be paid to the PWD for execution of other departments/agencies works by the PWD will be 12.5%, ie. half of the existing rate of 25%.

### xv) Performance Guarantee :-

The contractor who quotes very low rates will remitperformance guarantee with a view to curb the tendency to quote low rate and execute the works unsatisfactorily.

- (a) If the quoted rate for work is below 50%, it will be rejected.
- (b) If the quoted rate is between 25% and 50% below estimate rate, the contractor will remit performance guarantee equal to the difference between estimate PAC and quoted PAC. This will be released after satisfactory completion of the work.

### xvi) Time for executing agreement :-

Execution of agreements for works will be made within the time limit

prescribed as follows :-

- a) Time allowed for executing agreement without fine will be 20 days from the date of acceptance of tenders.
- b) Further time of 10 days shall be allowed to execute agreement by realising a fine of 1% of the PAC subject to a minimum of Rs 500 and maximum of Rs 15.000/-
- c) Tenders will be rejected if agreement is not executed within 30 days and work will be awarded to the next lowest tenderer as stipulated under clause 4.10.5 of the Code.

### xvii) Registration of Contractors :-

This clause has been modified vide GO(P) No.13/98/PWD dated 21-2-1998.

### xviii) Performance Certificate :-

The registering authority will maintain yearly performance certificate of contractors based on their performance in doing works undertaken by them. The renewal of the registration will be based on this performance certificate.

### xix) Handing over site of works :-

The contractor will take over charge of the site within 10 days after executing agreement and commence the work.

### xx) Tender conditions - examining of site conditions before submitting tender :-

The contractors will examine the site conditions and satisfy themselves of the availability of materials at nearby places, difficulties which may arise during execution etc. before submitting tenders for the work.

## xxi) Contractor's Technical Personnel to supervision :-

The contractor's technical personnel to supervise the work will be as follows: For works costing from Rs 10 lakhs to Rs 20 lakhs - one diploma holder For works costing above 20 lakhs - one degree holder For pre-qualification - one degree holder, one diploma holder

### xxii) Issue of Road Roller :-

The contractor will arrange road roller by himself, if not supplied by the Department.

### xxiii) Nomenclature for preparation of bill :-

Abbreviated nomenclature will be adopted for recording measurements and preparing bills. The accepting authority will decide the abbreviated nomenclature which will be underlined in the specification for each item in the schedule. A certificate will also be recorded at the end as "Certfied that for items where abbreviated nomenclature has been adopted, the work has been accepted as per full nomenclature of the corresponding items of the agreement."

### xxiv) The fee/limits for the various items will be enhanced as follows :-

<u>ltem</u>		Revised fee/limit
a) Fee for fitness certificate for High Schools		Rs 500/-
-do-	U.P. Schools	Rs 150/-
-do-	L.P. Schools	Rs 100/-
Note :- For unaided so	hools double the fee as	

Note: For unaided schools, double the fee as specified above shall be levied.

-do- for cinema theatre/permanent -do- semi permanent	Rs 500/- Rs 300/-		
b) Sanctioning working estimate provided	K\$ 300/-		
under lumpsum amount maximum limit	Rs 3 lakhs		
c) Limits for works in Raj Bhavan			
Original works	Rs 30,000/-		
Other residence	Rs 7,000/-		
Water supply	Rs 2,500/-		
Electrification	Rs 1,500/-		
d) Waiving of tender calls upper limit	Rs 3 lakhs		
e) Tender :- Period allowed between date of advertisement in Daily and tender date			
<ul> <li>i) Works costing upto Rs 2 lakhs</li> </ul>	5 days		
ii) Works costing Rs 2 lakhs to Rs 15 lakhs	10 days		
iii) Works above 15 lakhs	20 days		
0.0 . ( T. 1. D	4 40 00001		

f) Cost of Tender Documents [vide G.O(p)No 540/2008/Fin dated 01-12-2008]

	Cost of Tender Forms			
<u>Particulars</u>	Origina	<u>l</u>	<u>Duplicate</u>	
Works/Supplies costing Rs. 50,000/- or less	Rs.300/+VAT @ 1	12.5%	Rs.150/-+VAT @12.5%	
Works/Supplies costing above Rs. 50,000/- and upto Rs. 10 Lakhs	0.2% of the cost of the work rounded to the nearest multiple of 100 subject to a minimum of Rs. 400 and maximum of Rs. 1,500/- +VAT @ 12.5%  50% of the cost of the original upper rounded to the nearest multiple of Rs. 100/-+VAT@ 12.5%			
Works/Supplies costing morethan Rs. 10 Lakhs	0.15% of the cost of the work rounded to the nearest multiple of 100, subject to a maximum of Rs. 25,000/+VAT@12.5%		50% of the cost of the Original upper rounded to the nearest multiple of Rs. 100/-+VAT@12.5%	
g) Fine for belated execution	r limit	Rs 15,000/-		
h) <u>Cash Deposit/Solvency</u> A Category (cash depo B Category (cash depo C Category (solvency) D Category (solvency)		Non-Electric Rs 1 lakh Rs 50,000/- Rs 25,000/- Rs 15,000/-	Rs 25,000/- Rs 15,000/- Rs 10,000/-	

For cash deposit and solvency, National Savings Deposits specified in GO (P) 423/91/Fin dated 13-7-1991 will also be accepted.

i) Fine for late submission of application for renewal Rs 150/-

The revised PWD Code, incorporating the above provisions and detailed procedures will be issued shortly.

> (By Order of the Governor) MINNIE MATHEW Secretary to Government.

### **GOVERNMENT OF KERALA**

### Abstract

Irrigation Department - Pre-qualification of contractors - Revised orders issued.

### IRRIGATION (IRRN) DEPARTMENT

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GO(MS) No.84/98/Ir.D.

Dated, Thiruvananthapuram 13-8-1998

Read :- 1) GO(MS) 52/87/PW&T dated 7-7-87

- 2) GO(Rt) 158/93/Ir.D dated 8-2-93
- 3) GO(Rt) 1265/96/Ir.D dated 22-11-96
- 4) GO(Rt) 811/97/Ir.D dated 18-6-97

### ORDER

The system of pre-qualification of contractors was earlier adopted in Irrigation Department as per the Government Order read as 2nd paper above. Government have considered it necessary to amend the pre-qualification system earlier adopted in the light of the experience gained. In the National Highways Projects financed by the Government of India and in World Bank aided Projects, the system of pre-qualification of contractors has been adopted with a view to minimising the difficulties mentioned above. Under the pre-qualification system, contractors satisfying certain criteria alone are permitted to offer tenders. For original works sanctioned by Ministry of Surface Transport, Government of India for National Highways, pre-qualification limits are:

- (i) Upto Rs 500 lakhs Open tender
- (ii) Rs 500 lakhs to Rs 2000 lakhs 2 cover system
- (iii) Above Rs 2000 lakhs pre-qualification.
- 2. The system of pre-qualification of contractors adopted in the Public Works Department vide the Government Order read as 1st paper above was introduced in the Irrigation Department also as per the Government Order read as 2nd paper above. As per Government Order read as 3rd paper, Government had issued revised guidelines for selecting pre-qualified contractors in the Irrigation Department for the purpose of ensuring a more healthy competition. In the Government Order read as 4th paper above, Government have reconstituted the Committee for selection of pre-qualified contractors for Irrigation Department.
- Incorporating the conditions stipulated in the above Government Orders and after analysing the recommendations and suggestions made by the Chief

Engineer's Committee, Government are pleased to issue the following modified order for selection of pre-qualified contractors in Irrigation Department.

- 4. (1) The system of pre-qualification of contractors will be adopted for all works in the State by the Irrigation Department.
- (2) Tenders for execution of works shall be obtained from contractors pre-qualified according to the procedure laid down in the appendix to this order, for works and the estimated cost of construction as indicated below:
- a) For specialised work such as non-overflow section of dam, overflow structures such as spill way of dam, tunnel, large cut and cover etc. - Estimate cost of Rs 300 lakhs or more.
- b) Canal formation including CD works (excluding major aqueduct and cut and cover as specified above) and other irrigation works Rs 125 lakhs or more.
- c) Construction of aqueduct, bridge, bridge-cum-regulator, canal lock-cum-regulator and such other works Rs 100 lakhs or more.
- d) Construction of sea wall, flood bank, flood protection/Central works Rs 125 lakhs or more.
- (3) Contactor pre-qualification prior to invitation of bid may also be made in case of special projects involving complexity of design/construction and or where deemed necessary for quality assurance even if the cost of construction is below Rs 100 lakhs.
- (4) There should be a minimum of 4 (four) pre-qualified contractors to ensure fair and reasonable competition. If the number of contractors are less than four, even after repeated attempts for pre-qualification of the contractors for a work, then open tender system may be resorted to.
- 5. The selection of pre-qualification will be done by a Committee constituted as per the Government Order read as 4th paper above.

(By Order of the Governor)

ELIAS GEORGE SECRETARYTO GOVERNMENT

### **GOVERNMENT OF KERALA**

### **Abstract**

PWD - PWD Code and PWD Manual - Rules and Procedures Revisions - Orders issued. PUBLIC WORKS (H) DEPARTMENT

GO(P) No.83/2000/PWD

Dated, Thiruvananthapuram 18-12-2000 

1) G.O.(P) No.84/97/PW&T dated 19-8-97 2) G.O.(P) No. 13/98/PWD dated 21-2-98

### **ORDER**

- 1. The PWD Manual as amended by G.O. read as first para above provides that for extension of time of completion beyond the grace period, fine will be imposed on contractors at the rate of 1% of the probable amount of contract (PAC) for extensions upto 3 months and 2% for every 3 months beyond the first 3 months.
- In a meeting taken by the Minister (Irrigation & Labour) on 23-11-2000 in the presence of Minister (Finance and Excise) contractors pointed out that their bills remain unpaid for periods ranging from 2 to 3 years and that they have a problem in proceeding with works until payments are released against eligible part bills. Therefore, they have requested that fine imposed for extension of time of completion may be modified so as to allow exemption from payment of fine to those contractors for whom time of completion of work is extended on account of delays in payment of part bills. They have also requested that the agreement executing authority, who is departmental officer, may be empowered to grant such exemption.
- Govt. have examined the matter in detail and are pleased to add the following paras to sub-clause (b) of clause (ii) of para 2 of the Government Order read as first paper above.

No fine, however will be imposed on a contractor for extension of time of completion of the work if eligible part bill of the concerned work is pending for payment. The agreement executing authority will be the competent authority to grant such exemption.

The orders issued in Government Order read first paper above stands modified to this extent.

> (By Order of the Governor) Sd/-Joint Secretary to Govt.

Office of the Chief Engineer, PWD, National Highway and Administration, Thiruvananthapuram, Dated 13.01.2009

### TECHNICAL CIRCULAR

Sub:- Fixation of Standard Rent-Uniform Rates-reg.

Ref:- Technical Circular No. B1-59974/90 dated 18.01.2008, of the Chief Engineer,

PWD National High Way and Administration.

Item No.		ite/m2 n Rs.
1	Building with rubble in lime/cement mortar for foundation and	
	basement, brick in lime/cement mortar for superstructure, doors	
	and windows with country wood,	
	RCC roof slab or M.P. tiled roof over wooden rafters with ceiling etc.	
(a)	Single storeyed	6201
	Mosaic flooring will be separately measured and an extra rate of Rs. 362/m <sup>2</sup> allowed	
(b)	Portion like lean to verandah (open or trellised etc. and structure like	2972
	car porch to be valued separately) roofed with A.C. sheet or tiles	
(c)	For two storeyed building with specification as per item 1	
	(i) Ground Floor	6516
	(ii) First Floor	6201
(d)	For three storeyed building with specification as per item 1	
	(i) Ground Floor	6516
	(ii) First Floor	6201
	(iii) Second Floor	6516
	Proportionate increase of Rs. 315/m² for successive floors above	
	third floor can be allowed	
(e)	Single storeyed building without ceiling and other specification	5531
	as per item 1	
(f)	Out houses like bathroom garage etc. with specification as per item 1	3964
II	Building with thatched roof and with ceiling, doors, windows etc. in which country wood is used	4741
III	Semi-permanent shed with AC sheet or G.I. Sheet roofing over trusses etc.	3442
IV	For building constructed using teak wood for all wood work	
	add Rs. 960/m² to corresponding items	
V	For building constructed using teak wood partially add Rs. 360/m² to	
	corresponding items (this may be decided by the inspecting officer)	
VI	For areas like Ernakulam where foundations are costly Rs. 735/m <sup>2</sup>	
	may be added but the reason has to be specially stated. This does	
	not mean extra charges due to site condition as the general land value	Э
	will cover this extra.	
VII	Building constructed with specification as per item I and the roof is	6516
	with steel truss etc. for godowons and similar structures single storey	⁄ed
Note:	The above rates are fixed for the buildings constructed as per st	
	specification. The inspecting officers may fix a suitable rate as per site co	nditions
	·	

and actual specification proportionate to the above and subject to the above maximum. These rates may be followed unless the work is found to be substandard. For substandard works proper deduction may be made from the approved rates. For buildings constructed with laterite Rs.  $200/m^2$  is to be deducted from the rates noted above. For mud mortar construction for foundation and basement deduction of 2.5% may be effected from the above rates.

### Water Supply and Sanitary Fittings

No.	Specification	Rate Each in Rs.
1.	Water tap with connections	433
2.	Shower with connections	433
3.	Wash hand basin with waste connections etc.	3257
4.	Indian water closet with flush tank	2859
5.	Indian water closet without flush tank	1028
6.	European water closet with flushing cistern	4116
7.	Septic tank with connections up to 25 users capacity	12805

### **Electrical installations**

A. Wiring in open PVC conduit using 1 Sq.mm PVC insulated stranded single core copper wire with continues copper earth wire of No. 14 SWG size controlled with 6 A switch

Item	Speci	fication Rate/each	in Rs.
No.		Piano typ switch	e Mouldar type switch
1.	Light point with ceiling rose	544	609
2.	Light point without ceiling rose	528	584
3.	Call bell point without ceiling rose	546	618
4.	Stair case point with ceiling rose	912	964
5.	Fan point with ceiling rose	685	954
6.	Plug point in combined position	227	319

### B. Electrical Fittings

Item No.	Specification	Rate Each in Rs.
1	AC call bell	275
2	Batten light fittings with bulb	65
3	Bracket light fittings with bulb	250
4	Pendent lights fittings with bulb	65
5	Elliptical Bulkhead light with bulb	401
6	Square Bulkhead light with bulb	428
7	1 x 40 w Box type flu light fittings with tube on stiff (suspension down rod)	821
8	2 x 40 w Box type flu light fittings with tube on stiff (suspension down rod)	1180
9	1 x 40 w Box type flu fittings with tube on T.W. round block	696
10	2 x 40 w Box type flu fittings with tube on T.W. round block	1054
11	1 x 40 w Box type flu fittings with tube directly on wall	675

12	2 x 40 w Box type flu fittings with tube directly on wall	1033
13	1 x 40 w Box type flu fittings on angle iron frame work	725
14	2 x 40 w Out door type flu light fittings with tube	1923
15	300 mm sweep light duty exhaust fan	1174
16	1200 mm sweep electric ceiling fan with regulator and all accessories	1154
17	1400 mm sweep electric ceiling fan with regulator and all accessories	1230
18	15 A plug socket controlled with 15 A switch fitted on suitable size	278
	MS box & hylam sheet cover	

8. These rates shall come into effect from 01.04.2008.

Sd/-Chief Engineer PWD, N.H. & ADMINISTRATION

### **PUBLIC WORKS (H) DEPARTMENT**

GO(P) No.68/99/PWD

Dated, Thiruvananthapuram 14-7-1999

Read :- 1) GO(P) No.84/97/PW&T dated 19-8-1997

### ORDER

In the Government Order read above Government have issued orders modifying the existing Rules and proceedures in the PWD Code and Manual, as a part of its revision.

The President, All Kerala Government Contractors Association, Alappuzha District Committee in his letter read above has represented that there are various anomlies in the Government Order and he requested Govt. to allow him a personal hearing and to rectify the anomalies. He also filed an O.P. No. 18667/98-V in the High Court. The High Court in its judgement read as third above, has directed Government to consider and pass orders on the above representation of the Association within 3 months after hearing the petitioner.

Government have examined the various demands of the Association, in detail. The petitioner was heard by the Principal Secretary on 16-4-99. Government are pleased to modify the orders issued in the Government Order read above as detailed below.

(ii) (a) Extension of time of completion of work and fine.

The Tendering Authority will consider genuine request for extension of time of completion of work at the time of executing Agreemets taking into account the climatic conditions or other local problems at the site and grant extension of time up to three months. The Tendering authority shall record the reason in such action with facts and figures.

XVI (a) Time for executing Agreement.

The time allowed for executing agreement without fine will be 20 days from the date of Registration of the communication (selection notice) in the post office.

The Government Order stands modified to this extent.

Office of the Chief Engineer, PWD Buildings & Administration, Thiruvananthapuram - 695 033 Dated 20-01-1994

### **CIRCULAR**

Sub:- Revision of technical circular-regarding

Ref:- 1. Letter No. B/11939/85/dt 10.07.85 of the CE(R&B)Thiruvananthapuram.

Technical circulars have been issued by Chief Engineers of different branches of Public Works Department from time to time the reby resulting in different procedures and standards being followed in the different branches. The need for a unified standard and procedure of various works in the department has been pointed out by the Accountant General. Government have also directed vide No.42144/P3/87/PW&T/dt.2.02.1990 that technical circulars shall be issued only by the Chief Engineer, Administration.

The standards to be followed for various items for the construction and maintenance of road works in India are prescribed by the Indian standard Institution and the Indian Roads Congress, and for building works are prescribed by in the National Building code. The standards prescribed by these institutions have been diluted in the various technical circulars, as an economy measure.

Rubble and brick masonry works are being carried out in the department in cement morter 1:8 for buildings and in mud morter for compound walls. Similarly plastering is being done in cement mortar 1:4 and 1:5 for outside and inside walls respectively and for levelling course and flooring in c.c.1:5:10. These specifications do not confirm to the standards prescribed by the above institutions. It has been noticed that frequent maintenance is required for structures constructed with lean mixes resulting in excess long term financial commitment which exceeds the economy achieved during construction.

For painting walls, colour washing and white washing is being carried out for all buildings and water proof cement and plastic emulsion painting etc. are done only for prestigious buildings. Colour washing and white washing are being carried out every year. Due to the adoption of cheaper materials for painting the aesthetic appearence is badly affected. Moreover water proof cement paint serves weather proofing purpose also. Considering all these it would be more advantageous to government to use painting materials with better quality.

In patchworks for rectification of potholes; only sand seal coat is being used as an economy measure. But 6 mm chips are used for all surface renewals, the quantity of road surface is seen improved considerably. The Chief Engineers Committee meeting held on 3.01.94 has discussed the matter in detail. The committee observed that due to dilution in certain specifications, the quantity of Public Works could not be maintained to the prescribed standards. Also as frequent maintenance is required for most of the structures, the long term expenditure to be incurred for maintenance of works forfeit the economy achieved during construction.

The committee also observed that it would be advantageous for the Government

to adhere to long term benefits rather than adopting measures for short term benefit. In the circumstances the committees decided to revise all the technical circulars prevailing in the department with immediate effect As per the decisions of the committee the following standards shall be followed for all construction and maintenance works in the department hereafter.

- Random Rubble and brick masonry works shall be constructed in cement mortar 1:6 richer mikes shall be used if the stresses to be developed in a structure due to high loads necessitates its use. This shall be decided after detailed calculation of the stresses developed in the structure.
- 2. Plastering over brick work shall be in cm. 1:4, 12mm. thick and over RR masonry in cm. 1:4, 15mm. thick. Plastering over R.C.C slabs shall be in cm. 1:3, 9mm thick. Richer mixes may be used in case of a particular structure, if the design necessitates the same or such a standard is prescribed by the Bureau of Indian standards or such other agency. Mixes for plastering for septic tanks and water retaining structures shall be those prescribed by the Bureau of Indian standards or such other agencies.
- Levelling course for foundation and bottom course for drains shall be done in cement concrete 1:4:8:15cm. thick. Flooring for buildings shall be in c.c.1:4:8, 75 mm. thick.
- 4. Painting of walls shall be done with white washing, colour washing water proof cement paint, plastic emulsion etc. considering the importance of the structure and the frequency of painting, required for a building. White washing and colour for a particular shall be carried out every year and water proof cement and plastic emulsion painting once in two years synthetic enamel painting shall be done once in three years. It shall be of two coat for new surface and one coat for subsequent paintings.
- 6m.m. chips for seal coat shall be used for all patch works for rectification of potholes hereafter.'
- Use of brick jelly concrete for weather proofing shall be discontinued as it has been observed that its use has suggested the leaking in slabs in several places.
- 7. All modern developments and techniques in the field of construction and maintenance, shall be adopted for works in the department. The rate for the new items shall be got approved by the Technical sanction issuing authority. The rates shall be based on the current market price of these materials.
- 8. The performances of the new materials used shall be reported in due course, to the concerned Chief engineer directly by the field officer with all the supporting details.

All technical circulars issued till date in the above subjects stand cancelled.

Sd/-

C.E. Administration

### **GOVERNMENT OF KERALA**

No.59289/KI/2004/RD

Revenue (K) Department Thiruvananthapuram, Dated 22/12/2004.

### **CIRCULAR**

Sub:- Construction and maintenance check dams - guidelines - Reg.

The following guidelines are issued to ensure safety and accountability of existing check dams and construction of new check dams.

- All the private Land owners who have constructed check dams in their Lands should furnish information to the district administration.
- A technical team should inspect these check dams to know whether they confirm to the engineering/architectural norms.
- All the check dams which do not conform to the standard norms should either be strengthenend or demolished.
- 4. In future check dams shall be constructed only with the permission of Irrigation department as per approved plan and estimate. The department shall set standards for construction. There should be an upper limit for maximum, height especially in the high ranges.
- The irrigation department officer should inspect the check dam and certify the strength in every three years before monsoon.
- 6. The Land owner will be responsible for annual maintenance and up keep.
- A spill way and a silt clearence crevice shall be provided to each check dams.
   During the rainy season the silt clearence crevice and spill way shall be kept opened.
- 8. In the case of Government check dams, the Grama Panchayat will be responsible for its operations and maintenance.
- A beneficiary committee may be entrusted for the upkeep of the check dam.
   The above guidelines is to be observed scrupulously.

M. Aravindakshan

Additional Secretary

### HIRE CHARGES OF DEPARTMENTAL PLANT & MACHINERY

## PROCEEDINGS OF THE CHIEF ENGINEER (MECHANICAL), IRRIGATION, THIRUVANANTHAPURAM

### Present Shri. S. Vijayakumaran Nair

Sub : Revision of hire charges of departmental Plant and Machinery- reg.

Read: Order No. CMU/TECH/2185/93/Vol.II Dated 17-04-99

### Order No. CMU/K/299/00 Dated 8/2/2000

In the of order read above, hire charges of departmental plant & machinery has been revised now the hire charges of chain pulley blocks has been revised and the orders modified accordingly. The revised rates are shown in the statement appended. The revised rates shall come into force with effect from 01-05-1999.

- The rates fixed are exclusive of crew charges, fuel charges and other operating costs. These may be realised as per actuals. In case of crew charges, 25% extra, in addition to the salaries, shall be realised towards leave salary, pension contribution etc. of the crew.
- The rates fixed are for Government works. 50% extra of the rates proposed shall be collected for private work as per directions contained in Art. 316 (12) of KPWD code.
- 20% extra of the hourly rates shall be collected for additional hours worked after 8 hours normal operation in a day.
- 4. The minimum rate of hire charges for plant and machinery lent on hire shall be one day's rate except for heavy each moving machinery. For heavy earth moving machinery the minimum hire charges shall be 1/2 day's rate subject to the following conditions.
  - (a) Minimum charges of 1/2 day's rate will be applicable only when the machine is working for more than one contractor or on more than one work on the same day.
  - (b) In case work for less than four hours is only planned for any particular day, the minimum rate of recovery shall be for 1/2 day (4 hours).
  - (c) In case the work is planned for the whole day, but due to reasons beyond the control of the contractor, the work has to be stopped and the machinery has to idle, the recovery may be for 1/2 day only provided such stoppage of work does ot involve utilisation of the machinery for more than 4 hours. But if the machinery is idling due to no fault of the department, then full day hire charges shall be recovered.
- These rates are appicable only for hiring of departmental machinery and should not be used for any other purpose.

Sd/-

Chief Engineer (Mechanical)

# STATEMENT OF REVISED HIRE CHARGES OF DEPARTMENTAL PLANT AND MACHINERY

SI No.	Machinery	Approximate Capital cost	Туре	Daily Hire Charges	Hourly Hire Charges
1.	Concrete mixer (14/10 CFT), Diesel/Electric	1 20 000	С	240	4.4
2.	<b>,</b> '	1,38,000		348	44
2.	Concrete Mixer (10/7 CFT) Diesel/Electric	96,140	С	242	30
3.	Concrete Vibrator (Electric motor driven)	17,250	C	48	
4.	Concrete Vibrator (Diesel Driven)	31,050	С	86	
5.	Hot mix plant (6T/hr-10T/hr)	5,17,500	В	830	104
6.	Hot mix Plant (20T/hr-30T/hr)	6,90,000	В	1,107	138
7.	Excavator 90 CK	52,23,300	В	8,378	1,047
8.	Bull Dozer (D50-A15)	35,00,000	С	7,072	884
9.	Bull Dozer (D80-A12)	55,00,000	С	11,113	1,389
10.	Bull dozer (D12-A18)	95,00,000	С	19,195	2,399
11.	Air Compressor (upto 200 CFM)	3,75,000	С	735	92
12.	Air Compressor (200 CFM-300 CFM)	5,43,000	С	1,065	135
13.	Air Compressor (300 CFM-500 CFM)	8,20,000	С	1,605	200
14.	Pneumatic Rock drill/Jack Hammer	37,950	С	105	
15.	Welding Set (Diesel)	2,77,725	С	561	70
16.	Welding set (Electrtic Transformer)	69,000	С	139	
17.	Welding set (Electric Generator set)	1,27,995	С	259	32
18.	Chain pulley block (below 5 T)	12,507	С	36	
19.	Chain pulley block (5 T)	16,951	С	48	
20.	Chain pulley block (7.5 T)	2442		70	
21.	,, ,, (10 T)	32362		92	
22.	,, ,, (15 T)	88308		252	
23.	Pump sets (upto 10HP)	34,500	С	70	
24.	Pump sets (15HP-25HP)	80,500	С	163	20
25.	Pump sets (25 HP-50HP)	1,13,275	С	229	29
26.	Pump sets (50 HP-75HP)	1,91,763	С	387	48
27.	Pump sets (75 HP-100 HP)	2,21,663	С	448	56
28.	Pump sets (100HP-125HP)	3,43,850	С	695	87
29.	Tipper (5T-10T Capacity)	6,90,000	С	1,394	174
30.	Mini Dumper (1T)	2,76,000	С	558	70
31.	Mini Dumper (2T)	3,25,002	С	657	82

Sd/-Chief Engineer (Mechanical)

### **NATIONAL HIGHWAYS**

		<u>Kms</u>
NH 1	Delhi-Ambala-Jalandhar-Amritsar-Pakistan Border	456
NH 1A	Jalandhar-Jammu-Srinagar-Uri	663
NH 1B	Batote-Doda-Kishtwar	107
NH 2	Delhi-Agra-Kanpur-Allahabad-Varanasi-Calcutta	1490
NH 3	Agra-Gwalior-Indore-Dhule-Mumbai	1161
NH 4	Thane-Pune-Belgaum-Hubli-Bangalore-Chennai	1235
NH 4A	Belgaum-Ponda-Panaji	153
NH 4B	Nhava Sheva-Kalamboli-Palspe	27
NH 5	Baharagora-Cuttack-Bhubaneshwar-	
	Visakhapatnam-Vijayawada-Chennai	1533
NH 5A	Haridaspur-Paradwip	77
NH 6	Dhule-Nagpur-Calcutta	1645
NH 7	Varanasi-Nagpur-Bangalore-Kanyakumari	2369
NH 7A	Palayamkottai-Tuticorin	51
NH 8	Delhi-Jaipur-Ahmedabad-Mumbai	1428
NH 8A	Ahmedabad-Limbdi-Kandla	378
NH 8B	Bamanbore-Rajkot-Porbandar	206
NH 8C	Chiloda-Gandhinagar-Sarkhej	46
NH 9	Pune-Solapur-Hyderabad-Vijayawada	791
NH 10	Delhi-Abohar-Fazilka-Pakistan Border	403
NH 11	Agra-Jaipur-Bikaner	582
NH 11A	Dausa-Manoharpur	64
NH 12	Jabalpur-Bhopal-Kota-Jaipur	890
NH 13	Solapur-Bijapur-Chitradurga	491
NH 14	Beawar-Sirohi-Radhanpur	450
NH 15	Pathankot-Amritsar-Jaisalmer-Samakhiali	1526
NH 16	Nizamabad-Mancheral-Jagdalpur	460
NH 17	Panvel-Mangalore-Kozhikode-Edappally	1269
NH 17A	Marmagao-Cortalim	19
NH 18	Kurnool-Cuddapah-Chittoor	369
NH 20	Pathankot-Mandi	220
NH 21	Chandigarh-Bilaspur-Manali	323
NH 22	Ambala-Shimla-Rampur-Shipkila	459
NH 23	Chas-Ranchi-Talcher	459
NH 24	Delhi-Bareilly-Lucknow	438
NH 25	Lucknow-Jhansi-Shivpuri	319
NH 26	Jhansi-Lakhnadon	396
NH 27	Allahabad-Mangawan	93
NH 28	Lucknow-Gorakhpur-Barauni	570
NH 28A	Pipra-Raxaul-Nepal Border	68

NH 29	Gorakhpur-Varanasi	196
NH 30	Mohania-Patna-Bakhtiyarpur	230
NH 31	Barhi-Bakhtiyarpur-North Salmara-Nalbari-	250
1411 01	Charali Amingaon	1125
NH 31A	Sivok-Gangtok	92
NH 31B	North Salmara-Jogigopa	19
NH 31C	Near Galgalia-Chalsa-Hasimara-Sidli Junction	10
INIT STO	with NH 31 near Bijni	235
NH 32	Gobindpur-Dhanbad-Jamshedpur	179
NH 33	Barhi-Ranchi-Baharagora	352
NH 34	Dalkola-Baharampur-Calcutta	443
NH 35	Barasat-Bangaon-Bangladesh Border	61
NH 36	Nagaon-Dimapur	170
NH 37	Goalpara-Guwahati-Saikhoa Ghat	680
NH 37A	Kuarital-Junction with NH 52 near Tezpur	23
NH 38	Makum-Likhapani	54
NH 39	Numaligarh-Imphal-Myanmar Border	436
NH 40	Jorabat-Shillong-Bangladesh Border near Dawki	161
NH 41	Kolaghat-Haldia	51
NH 42	Sambalpur-Angul-Cuttack	261
NH 43	Raipur-Vizianagaram-Junction with NH 5	551
NH 44	Shillong-Jowai-Agartala	495
NH 45	Chennai-Tiruchirappalli-Dindigul	387
NH 45A	Viluppuram-Pondicherry	40
NH 46	Ranipettai-Krishnagiri	132
NH 47	Salem-Thrissur-Kanyakumari	640
NH 47A	Junction with NH 47-Willington Island	6
NH 48	Bangalore-Mangalore	328
NH 49	Kochi-Madurai-Dhanushkodi	440
NH 50	Nashik-Junction with NH 4 near Pune	192
NH 51	Paikan-Tura-Dalu	149
NH 52	Baihata Charali-Bander Dewa-Pasighat-	
	Sitapani- Junction with NH 37 near Saikhoaghat	850
NH 52A	Bander Dewa-Itanagar	25
NH 53	Junction with NH 44 near Badarpur-Imphal-Silchar	320
NH 54	Silchar-Aizawl-Tuipang	560
NH 54A	Theriat-Lunglei	9
NH 54B	Venus Saddle-Saiha	27
NH 55	Shilliguri-Darjiling	77
NH 56	Lucknow-Varanasi	285
NH NE 1	Ahmadabad-Vadodara (National Expressway)	93
NH 208	Kollam-Thirumangalam	81.280
NH 212	Kozhikode-Mysore	117.600
NH 213 NH 220	Kozhikode-Palakkad Kollam-Theni	125.35 189.585
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# NATIONAL HIGHWAYS IN KERALA

풀	PLACES	CHAINAGE	LENGTH in kms	NH STARTING AT	ROUTEOFNHS	NH ENDING AT
17	Thalappady to Edappally 18.05. to 438.827	18.05. to 438.827	420.77	Mangalore NH4	Panvel-Mangalore-Calicut- Edappally	Edappally NH 47
47	Walayar to Kaliyakkavila 182.200 to 599/000 416.800	182.200 to 599/000	416.800	Salem NH7	Salem-Kovai-Cochin- Trivandrum-Kanyakumari	Kanyakumari NH 7
47 A	Wellington Island to Kochi 0/000 to 5.920 Bypass	0/000 to 5.920	5.920	Cochin Port	Kundanoor-Ernakulam- Wellington Island @ Kochi	Kundanoor NH 47
49	Bodimettu-Muvattupuzha 119.017 to 286.610 167.593	119.017 to 286.610	167.593	Kundanoor NH47	Kundanoor NH47 Kochi-Munnar-Madurai- Dhanushkodi	Maduari- Dhanushkodi
208	Kollam-Aryankavu Thirumangalam	0/000 to 81/280	81.280	Kollam NH 47	Kollam-Aryankavu- Shenkottai-Thirumangalam	Near Madurai NH47
212	Kozhikode-Kellgel	0/000 to 117/600	117.600	Kozhikode NH17	Kozhikode-Sultan Bathery- Kellgel	Chennai-B'Lore NH219
213	Kozhikode-Palakkad	15.656 to 140.956	125.300	Feroke NH17	Kozhikode-Perinthalmanna- Mannarcadu-Palakkad	Palakkad NH47
220	Kollam Kottayam Kumily Theni	25.900 to 215/485	189.585	Kottarakara NH 208	Kottarakara-Kottayam Kanjirapally-Mundakayam- Peerumade-Kumily	Theni NH 49
	TOTAL		1525.570			

### SOFTWARE FOR CIVIL ENGINEERS

### Structural Analysis and Design

1 Staad Pro, Section wizard Research Engineers Intl
2 SAP 2000 Nonlinear Computers & Structures, Inc
3 ETABS, SAFE Computers & Structures, Inc

4 STRUDS SoftTech, India

5 RISA 3D RISA Technologies, LLC

6 NISA Civil Cranes Software International Ltd.

### **Drafting**

AutoCad, Architectural Desktop Autodesk Inc.
 Artlantis (3D rendering) Abvent Intrenational

3 Sketchup Google Inc. 4 3ds Max Autodesk Inc.

### **Building Information Modeling (BIM)**

1 Revit Autodesk Inc. 2 ArchiCad Graphisoft

### **Transportation**

1 MX Road Bentley

2 InRoads

3 AutoTurn, AutoSign (Add-in to AutoCad) 4 TransCad Caliper Corporation, USA

5 LinSig, Transyt (Traffic signal design)JCT Consultancy Ltd, UK

### Geotechnical

1 Geopro, Geolog, Georok, Geocal Datasurge, USA

2 SVFLUX,CHEMFLUX,SVSLOPE Soilvision systems ltd, SK

### Water and Waste Water

1 Water cad Haestad Methods, USA

2 Strom cad, SewerCad3 CulvertMaster, FlowMaster

### Geographical Information System (GIS)

1 ArcGIS ESRI, New York 2 Geomedia Intergraph, Madison

### Finite element and Modelling softwares

1 ANSYS Ansys Inc. Pennsylvania, USA

2 ALGOR ALGOR, Inc., USA

3 Scia Engineer CADS Software India Pvt. Ltd

4 SAP, Staad Mesher, NISA Civil

### **Project Planning / Integrated Solutions**

1 Primavera Oracle Corporation

2 MS Project Microsoft

3 GEOPÁK Site Geopak Corporation

4 Microstation Bentley

### **Simulation - Explosion and Blasts**

1 ExtremeLoading Applied Science Intl., LLC

2 Maya Autodesk Inc.

Developer / Language

1 MatLab MathWorks

2 C, C++, Java Public domain, Sun Microsystems

3 FORTRAN Public domain4 Visual Studio Microsoft

**Linux Supported** 

1 VariCAD Varicad, Czech Republic 2 Qcad (in Debian) RibbonSoft GmbH

**Document Preperation System** 

1 LaTex Freeware, www.latex-project.org

2 MS Office Package Microsoft

3 Openoffice Freeware, www.openoffice.org

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