# Southern Builder

Bulletin of Builders Association of India - Southern Centre

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Estd1941

OCTOBER 2021


*09.10.2021 மூன்றாவது மாநில அளவிலான மேலாண்மை மற்றும் பொதுக்குழு கூட்டம்*


*29.10.2021 கட்டுநர் தின விழா*

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Offical Journal of Builders' Association of India - Southern Centre. October - 2021

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# ஆசிரியர் மடல்

**அன்புடையீர் வணக்கம்,**

தேசியமும், தெய்வீகமும் எனது இரு கண்கள் என்று கூறி நாட்டின் சுதந்திரத்திற்கு பாடுபட்டவர் முத்துராமலிங்கத்தேவர் ஆவார். 1908ம் ஆண்டு அக்டோபர் 30ந்தேதி உக்கரவாண்டித்தேவர், இந்திராணி தம்பதியினருக்கு பசும்பொன் கிராமத்தில் பிறந்தார் தேவர் திருமகனார். மிகப்பெரும் நிலச்சுவான்தரான ஜமீன் குடும்பத்தில் பிறந்தாலும் ஏழை எளிய மக்களின்பால் மிகுந்த அன்புள்ளம் கொண்டவராகத் திகழ்ந்தார். அதன் காரணமாகத்தான் பிற்காலத்தில் தன் சொத்துக்கள் அனைத்தையும் பட்டியல் குல மக்களுக்கு தானமாக வழங்கினார் திரு பசும்பொன்தேவர் அவர்கள்.

விவேகானந்தர், வள்ளலார், ஆகியோரின் ஆன்மிக காருண்ய வாழ்க்கையில் நாட்டம் கொண்டவர். நேதாஜி சுபாஷ் சந்திரபோஸ் அவர்கள் தமிழகம் வந்தபோது நேதாஜியின் சுதந்திர வேட்கையால் ஈர்க்கப்பட்டார். பசும்பொன் தேவரின் அழைப்பை ஏற்று ஆயிரக்கணக்கான தமிழ் இளைஞர்கள் முன் வந்து சுதந்திரப்போரில் தங்களை ஈடுபடுத்திக்கொண்டனர். பசும்பொன் முத்துராமலிங்கத்தேவரின் வேகத்தையும், விவேகத்தையும், வீரத்தையும் கண்டு வியந்து தென்னாட்டு போஸ் தேவர் என்று பாராட்டியதோடு மறுபிறவி என்று ஒன்றிருந்தால் தான் தமிழனாகப் பிறக்க வேண்டும் என்று ஆசைப்படுவதாக கூறினார் நேதாஜி. நேதாஜி அவர்களை சந்தித்தபிறகு அவரால் ஈர்க்கப்பட்டு சைனா சில்க் போன்ற ஆடைகளை துறந்து கதர் ஆடைக்கு மாறினார்.

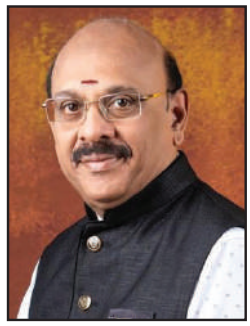
அரசியலைத்தேடி பசும்பொன் தேவர் சென்றதே இல்லை. ஆனால் அரசியல் அவரைத் தேடி வந்தது. 1937ம் ஆண்டு தேர்தலில் இராமநாதபுரம் ராஜா சேதுபதி அவர்களை எதிர்த்து போட்டியிட ராஜாஜி, சர்தார் பட்டேல், சத்தியமூர்த்தி ஆகிய தலைவர்கள் பசும்பொன் தேவர் அவர்களை முன்னிறுத்தினார்கள். தேர்தல் பரப்புரையின் போது வாய்ப்பூட்டு சட்டம் பாலகங்காதர திலகர் அவர்களுக்குப் பிறகு பசும்பொன் தேவர் அவர்களுக்குத்தான் பயன்படுத்தப்பட்டது. அதற்கு அவர் நான் பிறவி ஊமை அல்ல. அரசு என்னை ஊமையாக்கியுள்ளது. மக்களே நன்றி என்று மட்டும் கூறினார். தேர்தலில் மகத்தான வெற்றி பெற்றார்.

1946ல் சென்னை மாகாண சபைக்கு முதுகளத்தூரிலிருந்து போட்டியின்றி தேர்ந்தெடுக்கப்பட்டார். 1952, 1957, 1962 ஆகிய தேர்தலில் சட்டமன்றம், பாராளுமன்ற தேர்தலில் தேர்ந்தெடுக்கப்பட்டார். தமிழ், ஆங்கிலத்தில் சட்டமன்றம், பாராளுமன்றத்தில சிறப்பான உரையாற்றியிருக்கின்றார். ஒரே நேரத்தில் சட்ட மன்றத்திற்கும், பாராளுமன்றத்திற்கும் ஆகிய இரண்டு தொகுதிகளிலும் வெற்றி கண்டவர் பசும்பொன் தேவர் அவர்கள். வாழ்நாள் எல்லாம் நாட்டிற்காகவே வாழ்ந்தவர் 1963 அக்டோபர் 30ந் தேதி மறைந்தார். அவரின் புகழ் என்றும் மறையாது. ஆண்டுதோறும் அக்டோபர் 30 பசும்பொன் தேவரின் பிறந்தநாள் மற்றும் மறைந்த நாளன்று பசும்பொன் கிராமத்தில் அவர் நினைவிடத்தில் குருபூஜை நடைபெறும் தினத்தில் அமைச்சர் பெருமக்கள், அனைத்து கட்சித் தலைவர்கள் மற்றும் ஆயிரக்கணக்கான பொது மக்கள் கலந்து கொண்டு சிறப்பிக்கின்றனர்.

பசும்பொன் தேவர் அவர்கள் ஆன்மீகத்தில் இருந்திருந்தால் தமிழகத்திற்கு இன்னொரு விவேகானந்தர் உருவாகியிருப்பார் என்று கூறுவார்கள். பசும்பொன் தேவர் அவர்கள் ஒரு சாதித்தலைவர் என்பதை யாராலும் ஏற்றுக்கொள்ள முடியாது. அவர் சாதித்தலைவர் அல்ல. சமூகக்காவலர். அவர் சட்டசபையில் பட்டியல் இனத்து மக்களுக்கு ஆற்றிய உரை மிகவும் சிறப்பானது. அவர் கூறும்போது பட்டியல் இன மக்கள் அனைவரும் ஒன்றுபட்டிருக்க வேண்டும். ஆதிக்க சக்தியை எதிர்த்து போராடி மேன்மைக்கு வர வேண்டும் என்றுதான் அவர் கூறியிருக்கிறார். ஆதிக்கசக்தி என்றுதான் கூறியிருக்கிறாரே தவிர மேல் சாதி, கீழ் சாதி என்ற வார்த்தையைக் கூட அவர் பயன்படுத்தவில்லை. அந்த அளவுக்கு சொல்வன்மையும், மதிநுட்பமும் பெற்றவர் பசும்பொன் தேவர் அவர்கள்.

பசும்பொன் தேவர் அவர்களை நினைவு கூர்வதின் மூலம் இன்றைய அரசியல் மற்றும் ஆன்மீகத் தலைவர்கள் பசும்பொன் தேவர் அவர்களின் வாழ்க்கை முறைகளை பின்பற்றினால் இந்த நாடும், நாட்டு மக்களும் நலம் பெறுவர்கள்.

# மய்யத்தலைவர் மடல்



அன்பார்ந்த நண்பர்களே வணக்கம்,

கடந்த 08.10.2021 அன்று மாநில அளவிலான மய்யத்தலைவர்கள் மற்றும் துணைக்குழுத்தலைவர்கள் கூட்டமும் வரவேற்பு விருந்தோம்பலும், 09.10.2021 அன்று மாநில அளவிலான 3வது மேலாண்மை மற்றும் பொதுக்குழு கூட்டமும் ஓட்டல் Feathers-ல் நமது தென்னக மய்ய உபசரிப்பில் சிறப்பாக நடைபெற்றது. விழா ஏற்பாட்டு குழுத்தலைவராக செயல்பட்ட தென் மண்டல செயலாளர் திரு. K. வெங்கடேசன் அவர்களையும், அவர்களோடு இணைந்து பணியாற்றிய அனைத்து குழுத்தலைவர்கள் மற்றும் துணைத்தலைவர்களையும், கூட்டம் சிறப்பாக நடைபெற நிதியுதவி அளித்தவர்களையும் இந்நேரத்தில் பாராட்ட நான் கடமைப்பட்டுள்ளேன்.

தமிழக அரசின் ஏற்பாட்டில் 12.10.2021 அன்று நடைபெற்ற டெங்கு ஒழிப்பு விளிப்புணர்வு கூட்டத்தில் மாண்புமிகு மருத்துவம் மற்றும் மக்கள் நல்வாழ்வுத்துறை அமைச்சர் மா. சுப்பிரமணியன் அவர்கள், தென் சென்னை நாடாளுமன்ற உறுப்பினர் முனைவர் தமிழச்சி தங்கபாண்டியன் மற்றும் தியாகராயநகர் சட்டமன்ற உறுப்பினர் திரு. S. கருணாநிதி அவர்களும் கலந்து கொண்டனர். அகில இந்திய கட்டுநர் சங்கத்தின் சார்பில் தென்னக மய்யத்தின் தலைவரான நானும் கலந்து கொண்டேன்.

21.10.2021 அன்று கட்டுநர் தின விழாவின் ஒரு பகுதியாக அலுவலக அரங்கத்தில பொறியியல் மாணவர்களுக்கான "Role of Construction in Nation Building" என்ற தலைப்பில் பேச்சு போட்டி நடைபெற்றது. இதில் திரு. J.R. சேதுராமலிங்கம், திரு. A.N. பாலாஜி, திரு. K. வெங்கடேசன் ஆகியோர் நடுவர்களாக வீற்றிருந்து பேச்சுப்போட்டியினை நடத்திக்கொடுத்தனர்.

நமது 30வது அகில இந்திய கட்டுநர் மாநாட்டின் கையேட்டினை (Brochure) L&T நிறுவனத்தின் முன்னாள் தலைமை நிர்வாகி திரு. K.V. ரங்கசாமி அவர்கள் வெளியிட்டார்.

28.10.2021 அன்று நமது இணைப்பு சங்கங்களின் (Affiliated) கூட்டம் நமது அலுவலகத்தில் நடைபெற்றது. அதில் கட்டுநர் தற்போது நிலவும் கட்டுமானப் பொருட்களின் திடீர் விலையேற்றம் பற்றி விவாதிக்கப்பட்டதாடு இதன் மேல் நடவடிக்கை தொடரவும் முடிவு செய்யப்பட்டது.

கட்டுநர் தின விழா 29.10.2021 அன்று Park in Beach Resort–ல் வெகு விமரிசையாக கொண்டாடப்பட்டது. சுமார் 300 தொழிலாளர்களுக்கு சிறப்பு மருத்துவமுகாம் நடத்தப்பட்டது. மருத்துவ பரிசோதனை செய்து மருந்துகள் அளிக்கப்பட்டது. அகில இந்திய தலைவர் திரு. R.N. குப்தா அவர்கள் சிறப்பு விருந்தினராக கலந்து கொண்டு விழாவினை சிறப்பித்தார். பல்வேறு கலை நிகழ்ச்சிகளும், தொழிலாளர்களுக்கு சிறப்பு விருந்து, பரிசுப்பொருட்களும் வழங்கப்பட்டது. நமது நிரந்தர உறுப்பினரும், தாம்பரம் மய்யத்தின் சாசனத்தலைவரும், நாங்குநேரி சட்டமன்ற தொகுதி உறுப்பினருமான திரு. ரூபி R. மனோகரன் அவர்களின் சேவையை பாராட்டி அவருக்கு Citation மற்றும் டர்பன், மலர் மாலை அணிவித்து கவுரவிக்கப்பட்டார். கட்டுநர் தின விழாவிற்கு நிதி உதவி அளித்த அனைத்து உறுப்பினர்களுக்கும் எனது மனமார்ந்த நன்றியினை உரித்தாக்குகிறேன்.

30.10.2021 அன்று நமது மய்ய அலுவலகத்தில் அகில இந்தியத்தலைவர் திரு. R. N. குப்தா அவர்களோடும், தலைமையக நிர்வாகிகளோடும் 30வது அகில இந்திய கட்டுநர் மாநாட்டுக்குழுத் தலைவர் திரு. R.இராதாகிருட்டிணன் மற்றும் நிர்வாகிகளும் கலந்து கொண்ட ஆலோசனைக் கூட்டம் நடைபெற்றது. அதில் மாநாட்டிற்கான முக்கிய ஆலோசனைகள் மேற்கொள்ளப்பட்டது. நமது அகில இந்திய கட்டுநர் மாநாட்டினை வெகு சிறப்பாக நடத்துவதற்கு அனைத்து உறுப்பினர்களும் தங்களது முழு ஆதரவினை தந்து ஒத்துழைக்குமாறு அன்போடு வேண்டுகிறேன்.

இதுவரையிலும் பதிவு செய்யாத உறுப்பினர்கள் உடனடியாக பதிவு செய்து கொள்ளுமாறு கேட்டுக் கொள்கிறேன்.

என்றும் அன்புடன்
**L. சாந்தகுமார்**

# DISASTER-RESISTANT STRUCTURES

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## Curing of concrete

Concrete work requires water curing for a minimum of 14 days so as to gain strength; otherwise the gain in strength is low and concrete becomes brittle. Concrete slabs may be kept under water by ponding water over it by making barriers around the edges. Columns should be kept covered with wet, empty gunny bags. Keeping the side forms intact on the beam webs and column sides prevents the evaporation of water from the concrete surface and helps in curing. Covering any concrete surface with polythene sheets after wetting the surface helps retain the moisture for longer periods of time. Curing should be continuous and not intermittent.

Construction joints When a joint is to be made, the surface of the concrete should be thoroughly cleaned and all laitance removed. The surface should be thoroughly wetted and covered with a coat of neat cement slurry immediately before placing new concrete. Construction joints in floors should be located near the middle third of the spans of slabs, beams, or girders, unless a beam intersects a girder at this point, in which case the joints in the girder should be offset by a distance equal to twice the width of the beam. Keys should be provided for transfering shear through the construction joint. A polymer bonding agent can be used between the old and new concrete for good performance of the construction joints.

## Typical material properties required

Concrete is constructed in such a way that it has the desired strength for the required use. Its strength is defined on the basis of the 28-day cube crushing strength. For use in buildings, cube strength Fc between 20 and 30 N/mm2 will be adequate for RC work.

The concrete mix is accordingly designed for M20 or M30 grade concrete. M20 grade means the characteristic strength of concrete fck = 20 N/mm2. However, the mean strength Fc for this concrete will be about 24 N/mm2. It is preferable to use M30 grade concrete in coastal areas. The mass density of RC is about 24 kN/m3 and its modulus of elasticity is related to its strength. Since the stress–strain characteristics are non-linear, the value of the modulus of elasticity is ambiguous.

It is important to know that the tensile strength of concrete is only about one-tenth of its compressive strength. The diagonal tension caused by seismic shear forces, if not thoroughly protected by well-designed stirrups or ties, can lead to wide cracking and failure.

Concrete is a brittle material and weak against impact shock and vibrations. Reinforcing steel imparts ductility to it. The compressive strength as well as straining capacity can be greatly increased by using closely spaced lateral stirrup ties or spiral reinforcement. This is an important method for improving the earthquake resistance of reinforced columns and frames.

The critical zones in reinforced concrete frames where ductility of sections and confinement of concrete by closely spaced or spiral stirrups are essential are the following.

(a) Ends of beams up to a length of about twice the depth of the beam, where large negative moments and shears develop, are likely locations for plastic hinges. At these points, shear and moment reversal is possible under large lateral forces.

(b) Ends of columns where maximum moments develop due to lateral forces. Values of maximum column moments closely approaching the plastic moment capacity can be expected and these moments are likely to undergo full reversal. High lateral shears can develop based on moments of opposite sign at the column ends and these shears can undergo full reversal. The length of such zones is about one-sixth of the clear height of the columns between floors or the dimension of the column section in the plane of the frame.

(c) Joint regions between beams and columns undergo very high local shears; Full reversal is likely in these regions. Diagonal cracking and local deformation may cause a significant part of the rotation at the joints, increasing the lateral displacement of the frame.

## Detailing of beams

Longitudinal steel Both the top and bottom faces of beams should be reinforced throughout. When reinforcement is required by calculation, the percentage should correspond to that required for ductile behaviour. The recommended limits on the steel area ratio are shown in Table 26.8.

Table 26.8 Recommended limits on the steel area ratio in beams

| Concrete | Steel | $\rho$ max | $\rho$ min |
|---|---|---|---|
| M20 | MS (Fy = 250 MPa) | 0.011 | 0.0035 |
| | HSD (Fy = 415 MPa) | 0.007 | 0.0022 |
| M30 | MS (Fy = 250 MPa) | 0.015 | 0.0048 |
| | HSD (Fy = 415 MPa) | 0.009 | 0.0029 |

Fy: Yield strength of reinforcement

MS: Mild steel, HSD: high-strength deformed bars

$$\rho = \frac{A_s}{Bd}; \rho_{\min} = \frac{A_{s\ \min}}{Bd}; \rho_{\max} = \frac{A_{s\max}}{Bd}$$

Minimum steel should consist of two bars of 12 mm diameter in the case of mild steel (MS) and 10 mm diameter in the case of high-strength deformed (HSD) bars are used. The detailing of the beam reinforcement is shown in Fig. 26.21.

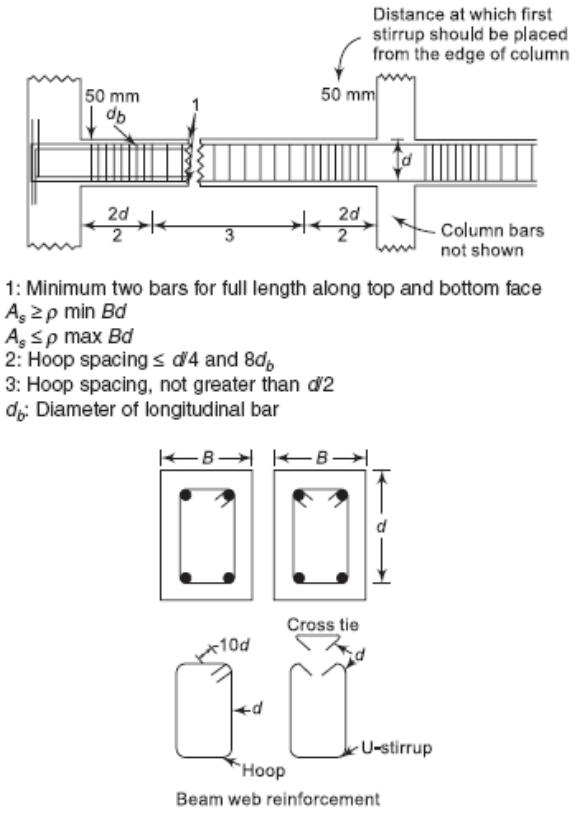



Fig. 26.21 Detailing of beam reinforcement

Splicing of steel All longitudinal bars should be anchored or spliced for full strength development. All splices should be contained within at least three stirrups at each end and one in the middle of the splice so as to avoid spalling of the cover concrete (Fig. 26.22).

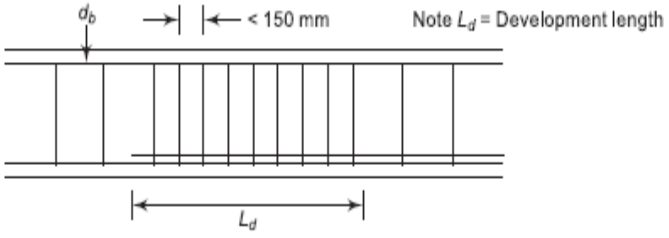



Fig. 26.22 Splicing in beams

## Transverse stirrups

The ultimate shear strength of the beam should be designed to be more than its ultimate flexural strength. Vertical shear stirrups should be closely spaced, at not more than one-fourth of the effective depth at the end regions, marked 2 in Fig. 26.21. The spacing can be increased to d/2 in the middle region, marked 3 in the same figure.

## Detailing of columns

### Column section

In view of the earthquake force acting in all directions, a square section of columns is better than a rectangular section. Typical column and joint reinforcement placement detail to be adopted for effective disaster resistance is shown in Fig. 26.23.

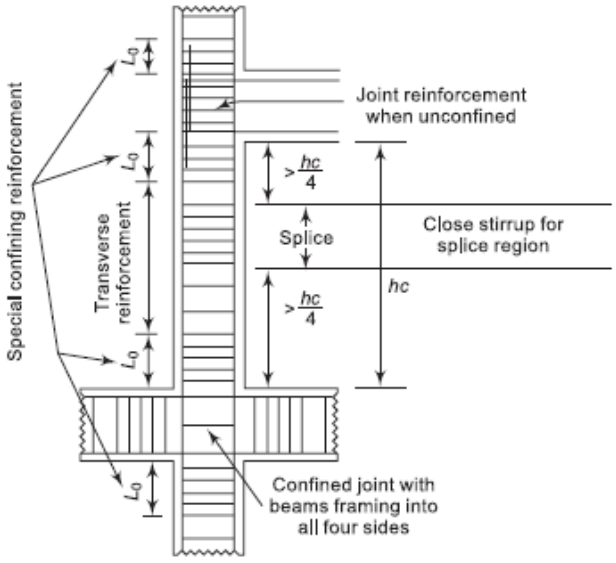



Fig. 26.23 Column and joint detail

### Longitudinal steel

Vertical reinforcement should be distributed on all the faces of the columns. The use of eight vertical bars is preferable to four bars of equal area; the minimum diameter of the bars should be 12 mm.

### Lateral reinforcement

Concrete confined within spirals is stronger and much more ductile as compared with plain concrete or that containing widely spaced stirrups. The behaviour of columns can be much improved by using closely spaced ties with adequate anchorage at the ends in the form of suitable hooks. In a length of about 450 mm near the ends of the columns, a spacing of not more than 100 mm should be adopted for achieving adequate ductility.

### Corner columns

The corner columns of buildings are stressed more than any other column due to biaxial bending and must, therefore, have steel distributed on all faces and closely spaced lateral ties.

### Connections

In the connections, the beam and column bars must be well anchored in the compression zone so as to achieve their full strength. At places where the beams on all four sides do not confine the joint, it is necessary to place the closely spaced ties in the column throughout the height of the joint as well.

Typical recommended details of connections in earthquake-resistant frames are shown in Figs 26.24–26.29. The following abbreviations are used in the illustrative sketches.

S2: maximum value = h/4 or 16d, whichever is smaller, where d is the bar diameter of the beam reinforcement

S3: maximum value = h/2

S4: value 75–100 mm

S5: maximum value = bk/2 or 200 mm, whichever is smaller

S6: optimum value 50 mm

$L_0$: length of overlap required to develop full tensile strength ~55d including bends or hooks

$L_d$: anchorage length to develop full tensile strength ~55d including bends or hooks

Diameter of stirrup bar in beam and column: minimum = 6 mm, preferable = 8 mm

Figure 26.24 shows the connection between the roof beam and the exterior column. Figure 26.25 shows the connection between the floor beam and the interior column. Figure 26.26 shows the interior joint between a haunched beam and the interior column. Figure 26.27 shows the connection between the floor beam and the exterior column. Figure 26.28 shows the column footing and the foundation/plinth beam. Figure 26.29 illustrates the provision of confining reinforcement in the column footing.

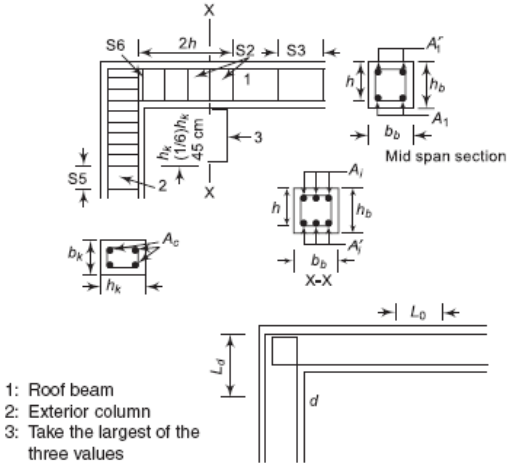



Fig. 26.24 Connection between roof beam and exterior column

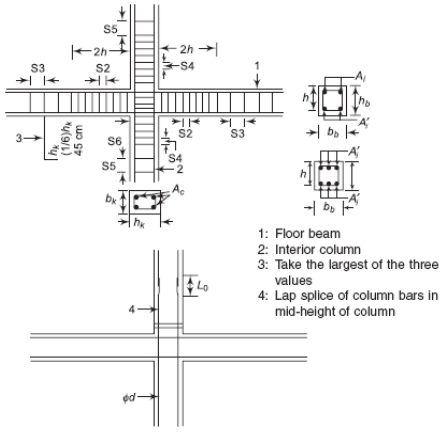



Fig. 26.25 Connection between floor beam and interior column

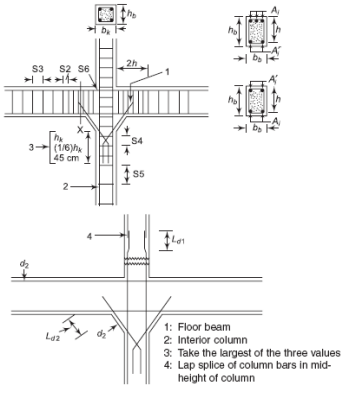



Fig. 26.26 Interior joint between a haunched beam and column

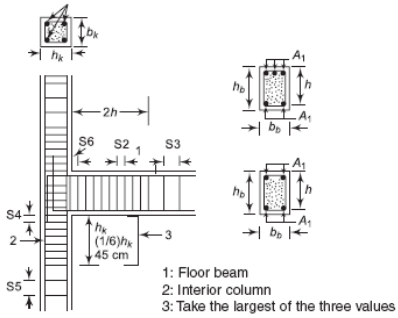



Fig. 26.27 Connection between floor beam and exterior column

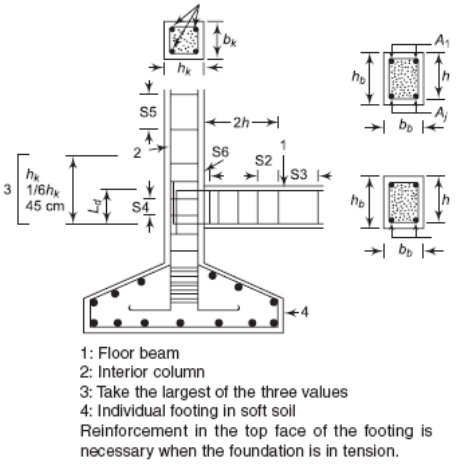



Fig. 26.28 Column footing and foundation/Plinth beam

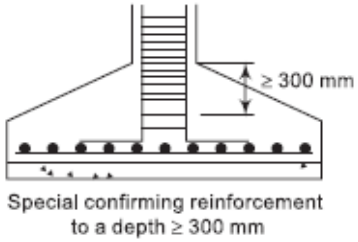



Fig. 26.29 Provision for confining reinforcement in footing

### 26.2.8 Construction and Planning Aspects for Cyclones

The following constructional and planning aspects help in reducing damages during cyclones and heavy winds.

#### Overhangs

For the purpose of reducing wind forces on the roof, a hipped or pyramidal roof is preferable to a gabled roof. In areas of high wind or those located in regions of high cyclonic activity, lightweight [galvanized iron (GI) or asbestos cement (AC)], low-pitch roofs should either be avoided or strongly held down to purlins. Pitched roofs with slopes in the range of 22°–30°, i.e., with pitch equal to 1/5 to 1/3.5 of the span, not only reduce the suction on the roofs but also facilitate quick drainage of rain water.

#### Wall openings

Openings in general are areas of weakness and stress concentration, but are needed essentially for lightning and ventilation. The openings in load-bearing walls should not be within a distance of h/6 from the

inner corner for the purpose of providing lateral support to cross walls, where h is the storey height up to the eave level.

Openings just below the roof level should be avoided except two small vents without shutters. These should be provided in opposite walls.

The failure of any door or window on the windward side may lead to adverse uplift pressures under the roof. Hence the openings should have strong holdfasts as well as closing/locking arrangements.

### Glass panelling

One of the most damaging effects of strong winds or cyclones is the extensive breakage of glass panes caused by high local wind pressure or the impact of flying objects in air. Large-sized glass panes may shatter because they are too thin to resist the local wind pressure. The way to solve this problem is to provide thicker, well-designed glass panes. Pasting thin plastic film or paper strips can strengthen the glass panes during cyclone seasons temporarily.

### Foundation

Buildings usually have shallow foundations on stiff sandy soil and deep foundation in liquefiable or expansive clayey soils. It is desirable that information about soil types be obtained and estimates of safe bearing capacity made from the available records of past constructions in the area and by proper soil investigation. The tidal surge effect diminishes as it travels on shore, which can extend even up to 10 to 15km. Flooding causes the saturation of soil and this significantly affects the safe bearing capacity of the soil. In flood-prone areas, the safe bearing capacity should be taken as half of that for dry ground. Also the likelihood of any scour due to the receding tidal surge needs to be taken into account while deciding on the depth of the foundations and the protection works around a raised mound to be used for locating important community buildings.

### Building on stilts

When a building is constructed on stilts, it should be properly braced in both the principal directions. This will provide stability to the complete building under lateral loads. Knee braces will be preferable to full diagonal bracing so as not to obstruct the passage of floating debris during a storm surge.

### Masonry walls—external walls

All the external walls or wall panels must be designed to resist the out-of-plane wind pressures adequately. The lateral load due to the wind is finally resisted either by all walls lying parallel to the lateral force direction or by RC frames to which the panel walls are fixed using appropriate reinforcement, such as ‘seismic’ bands at plinth and lintel levels.

### Strengthening of walls against high winds/ cyclones

For high winds in cyclone-prone areas it is found necessary to reinforce the walls by means of reinforced concrete bands and vertical reinforcing bars as for earthquake resistance.

### Framed buildings

In RC framed constructions, the frame comprises of rigidly connected beams and columns or posts. In steel and timber constructions, the complete structural framing should be adequately braced both in the vertical and the horizontal planes.

(a) Loading: The different loads and load combinations to be considered for the design are given in IS: 875 (parts 1–4). The dead loads, superimposed loads, wind loads, and snow loads to be considered are given in parts 1, 2, 3, and 4, respectively.

(b) For enclosing the space it is necessary that cladding be provided, firmly secured to columns or posts, on all the external faces and wherever partitioning is required. The panel walls should be designed for out-of-plane forces.

(c) Bracing: Adequate diagonal bracings with strong end connections should be provided in steel/timber frames in both the horizontal and vertical planes to improve the lateral load resistance. At least two end bays should be braced in the vertical and horizontal planes.

(d) Anchoring: The frame columns and shear wall, where used, should be properly anchored to the foundation against the uplift forces. Usually a monolithic footing is provided, which provides due stability against uplift. In the case of steel frames the columns should be properly tied to the flooring through anchor bolts. For timber posts usually cross pieces are nailed at the bottom end of the post and buried into the ground to provide the necessary anchorage.

### Foundations

The drainage around the building must be improved to prevent water stagnation. All the posts should be properly anchored into the ground or in reinforced cement concrete footing. Alternatively, the posts with cross members connected at the lower ends should be embedded in the ground for a minimum depth of 750 mm. Walls are raised from a well-compacted lean concrete bed or well-compacted ground from a minimum depth of 450 mm on the firm foundation or footing.

### Floors

Floors may consists of the following

- RC slabs
- wooden or RC joists carrying brick tiles, stones slabs, or reeds with clay topping
- Prefabricated RC elements of various designs placed side by side

### Construction of roofs

Depending upon the construction materials used and the geometrical aspects, roofs can be broadly classified into the following two main types:

- flat roofs of various types
- pitched roofs with various covering materials

### Flat roofs

In view of large uplift forces, particularly if the wind speed exceeds 55 m/s, the total roof weight should preferably be kept around 375 kg/m2. Lighter roofs

should be designed for net uplift forces and properly held down to the supporting beams/walls, etc.

### Pitched roofs

The main load-bearing structural members are timber or steel trusses, purlins, and bracings. It will be safer to use sheeting with adequate fixtures; U-bolts are recommended in place of J-bolts for anchoring the sheetings.

Under high-velocity wind along the ridge of the pitched roofs, the suction forces may exceed the dead loads of the roof appreciably, causing compression in the bottom chord and stress reversal in all truss members in general. Therefore, buckling considerations in the members of the roof trusses, which are normally under tension, assume significance. Therefore, the main ties of roof trusses also require lateral bracing and strutting against buckling in lateral direction.

### Ferro-cement as a roofing material

Ferro-cement has the advantage of reduced dead weight compared to an RC roof, as well as better corrosion resistance. This new material could be used for flat roof or supporting walls/beams against the wind uplift forces. We will discuss more about this technology in a later chapter.

### Roof covering

Clay tile roofs Owing to lower dead weight, these roofs may be unable to resist the uplifting force and thus experience heavy damage, particularly during cyclones. Anchoring of roof tiles into the RC strap beam is recommended for improved cyclone resistance. As an alternative to the bands, a cement mortar screed, reinforced with galvanized chicken mesh, may be laid over the entire tiled roof.

Thatch roof A thatched roof should be properly tied down to the wooden framing underneath by using organic or nylon ropes in a diagonal pattern. After a cyclone warning is received, a rope net properly anchored to the ground should preferably hold down all the lighter roofs. The probability of a fire hazard to the thatch can be reduced by spraying it with a fire-retarding coating at periodic intervals.

Anchoring of roof framing to walls/posts The connection of the roof framing to the vertical load-resisting elements, i.e., the walls or posts, by providing properly designed anchor bolts and base plates is equally important for the overall stability of the roof. The roof framing should be anchored to the masonry wall through anchor bolts embedded into concrete bed blocks.

Flutter In order to reduce wind-induced flutter/vibration of the roof in cyclonic regions, it is recommended that all members of the truss and the bracings be connected at the ends by at least two rivets/bolts or proper welds. Further, the cross-bracing members should be welded/ connected at the crossings to reduce the vibrations.

## 26.3 Retrofitting of Existing Buildings

In engineered constructions, the maximum wind forces should be evaluated as per the wind code and the various elements checked for the worst combination of dead and live loads to identify the points of weakness requiring retrofitting. Some of the vulnerable parts may need special attention. They are indicated below.

### 26.3.1 Lighter Roofs

(a) In the case of light roofs [asbestos cement (AC) or corrugated galvanized iron (CGI) sheeting], the connections near the edges should be strengthened by providing additional U-bolts. Mild steel flat anchored at intervals onto the purlin through sheeting may be provided to hold down the roof. The J-bolts used earlier may be replaced by U-bolts.

(b) All projections in roofs should be properly checked for strength against uplift and tied down if found necessary; particularly, if the projection is longer than 500 mm.

(c) All metallic connectors for the different components of the roof should preferably be of non-corrosive material, or else must be galvanized or painted and checked before each cyclone season and the doubtful ones replaced.

(d) There must be proper bracings in the plane of the rafters, in the plane at the eave level, and in the vertical plane of the columns along both the axes of the buildings in sufficient number of panels, which is determined by proper calculations.

(e) Flat roofs may be integrated to behave as horizontal diaphragms either weighed down by dead weights or held down against uplift forces.

### 26.3.2 Framed Buildings

(a) In the case of a framed structure, the total system requires to be properly braced. If the existing lateral strength or bracing is inadequate, braces are added to improve the overall stability.

(b) The beam–column junction should be inspected and repaired.

(c) Undesirable openings in the walls, especially near the corners or edges, should be closed permanently to improve the stability.

(d) Wherever corrosion is detected, it should be attended to by going for proper rehabilitation if necessary.

### 26.3.3 Load-bearing Walls

(a) Weak walls must be identified and provided with buttresses to improve the lateral load resistance of long walls, achieving cross wall spacing a less than $a/t < 40$ (t is the thickness of wall), thus reducing the unsupported lengths.

(b) If horizontal bands are not provided in the original construction, the exterior perimeter maybe belted all around by using ferro-cement or steel belts in the spandrel wall portion between the lintel and eave/roof levels. This will prevent the diagonal cracking of piers.

### 26.3.4 Glass Panelling

(a) Adding battens at appropriate intervals reduces the size of the glass panes to be used. Fixing adhesive tapes, along and parallel to diagonals, at 100–150 mm spacing prior to each cyclone season strengthens large glass panes. Alternatively, a thin plastic film can be pasted on both faces of the panes to prevent

shattering of glass in case of damage.

(b) A protective cover in the form of a mesh or iron grill can be provided to prevent the breakage of glass panes by flying debris, which act like missiles.

### 26.3.5 Foundations

(a) Proper drainage should be provided around the building to prevent pooling of water in its vicinity.

(b) The plinth should be protected against erosion by using suitable pitching.

### 26.3.6 Non-engineered Constructions

(a) A thatched roof should be properly tied to the timber frame underneath. The use of metallic/synthetic connectors is desirable. Waterproof mud plaster may be used to make the roof leakproof.

(b) In the case of tiled roofs, the overlaps should be joined using cement mortar to provide additional stability.

(c) When re-laying a roof, its slope should be changed to about 20° to 30° to reduce the wind suction on the roof and thus the damage vulnerability. At the same time, an eave-level wooden band should be introduced and integrated with the wall.

(d) When a wooden frame is used for the structure of a building, it should be properly braced in both the horizontal and vertical planes by installing knee braces or cross ties.

(e) For greater durability of a mud wall against rain, water, etc., the external face of the wall up to 1.0 to 1.5 m height above the plinth level should be covered with burnt clay tiles laid in a 1:6 cement mortar mix.

(f) The roof rafters should be properly tied to the posts using metallic strap connectors.

(g) All openings very close to the wall edges should be closed. All asymmetric non-closable openings should be filled up to eliminate any unfavourable roof pressure from within. Two small vents in opposite walls close to the roof may be left open.

(h) It is advisable that before the cyclone season, a protective net be provided on the roof and securely tied to the ground to prevent the flying off of a very light roof.

## 26.4 Repair and Strengthening of Buildings

The problems of repairs, restoration, and seismic strengthening of buildings are briefly stated below.

(a) Before the occurrence of a probable disaster, the required strengthening of weak buildings must be determined by a survey and analysis of the structures.

(b) Just after a damaging disaster, temporary supports and emergency repairs must be provided so that precariously standing buildings may not collapse during aftershocks and the less damaged ones can be quickly brought back into use.

(c) The real repair and strengthening problems are faced in the phase after the disaster when things start settling down. At this stage, the type of action to be taken—repairs, restoration, or strengthening—is to be decided. The cost, time, and skill required for each of these three actions are quite different.

The method of repair and strengthening naturally depends to a large extent on the structural scheme and materials used for the construction of the original building in the first instance, the availability of a feasible technology that can be adopted quickly, and the amount of funds that can be mobilized for the task. Some methods, such as 'splints and bandages', 'wire mesh with gunite', and 'epoxy injection', enable repairing as well as strengthening of the buildings.

### 26.4.1 Repair

Simple repair does not intend to improve the structural strength of the building and can be very deceptive as far as meeting the strength requirements for facing the next disaster is concerned. The actions in this category will include the following:

- patching up defects such as cracks and fall of plaster
- repairing doors and windows and replacing glass panes
- checking and repairing electric wiring
- checking and repairing gas pipes, water pipes, and plumbing services
- re-building non-structural walls, smoke chimneys, boundary walls, etc.
- re-plastering of walls as required
- rearranging disturbed roofing tiles
- re-laying cracked flooring at the ground level
- redecoration—white washing, painting, etc.

### 26.4.2 Restoration

Restoration is a procedure adapted to regain the strength the building had before the damage occurred. This type of action must be undertaken when there is evidence that the structural damage can be attributed to exceptional phenomena that are not likely to happen again and that the original strength provides an adequate level of safety.

The main purpose of restoration is to carry out structural repairs to load-bearing elements. It may involve cutting portions of the elements and rebuilding them or simply adding more structural material so that the original strength is more or less restored. The process may involve inserting temporary supports, underpinning, etc. Some of the approaches used are as follows.

(a) Removal of portions of cracked masonry walls and piers and rebuilding them in richer mortar. The use of non-shrinking mortar is preferable.

(b) Addition of reinforcing mesh on both faces of the cracked wall, holding it to the wall through spikes or bolts, and then covering it suitably. Several alternatives for this have been used.

(c) Injecting epoxy-like material into the cracks in walls, columns, beams, etc.

### 26.4.3 Strengthening of Existing Buildings

The disaster behaviour of old existing buildings is affected by their original structural inadequacies, material degradation due to aging, and alterations carried out during their use over the years, such as making new openings, adding new parts, and inducing asymmetry in the plan and elevation.

Strengthening is an improvement over the original strength, which when evaluated for a building indicates that the existing strength is insufficient and restoration alone will not be adequate for resisting future disasters.

### 26.4.4 Repair Materials

The most common materials used for damage-repair works of various types are cement and steel. In many situations, non-shrinking cement or an admixture such as aluminium powder and ordinary Portland cement is suitable. Steel may be required in many forms, such as bolts, rods, angles, channels, expanded metal, and welded wire fabric. Wood and bamboo are the most common materials used for providing temporary supports, scaffolding, etc., and are required in the form of rounds, sleepers, planks, etc.

### Shotcrete

Shotcrete is a method of combining sand and Portland cement mixed pneumatically and conveying the mixture in the dry state to the nozzle of a pressure gun, where water is mixed and hydration takes place just prior to expulsion. The material bonds perfectly to the properly prepared surface of the masonry or concrete. Its versatility of application to curved or irregular surfaces and its high strength after application and good physical characteristics make this technique an ideal means to achieve better structural capability for walls and other elements.

### Epoxy resins

Epoxy resins are excellent binding agents with high tensile strength. They are chemical preparations, the compositions of which can be changed as per requirements. The epoxy components are mixed just prior to application. The low-viscosity product can be injected into small cracks. The higher viscosity epoxy resin can be used for surface coating or filling larger cracks or holes. The epoxy mixture strength depends upon the temperature of curing (lower strength is associated with higher temperature) and method of application.

### Epoxy mortar

For larger void spaces, it is possible to combine epoxy resins of either low viscosity with sand to form epoxy mortar. Epoxy mortar mixture has higher compressive strength, higher tensile strength, and a lower modulus of elasticity than cement mortar. Thus it can be used for repair in RCC works.

### Quick-setting cement mortar

Quick-setting cement mortar is patented and was originally developed for use as a repair material for reinforced concrete floors adjacent to steel blast furnaces. It is non-hydrous magnesium phosphate cement with two components, a liquid and a dry solid. These components can be mixed in a manner similar to Portland cement concrete.

### Gypsum cement mortar

Gypsum cement mortar has very low strength. It is a workable mortar and is used for finishing and plastering cracks.

### Mechanical anchors

Mechanical anchors employ the wedging action to provide anchorage. Some of these anchors provide both shear and tension resistance. Alternatively, chemical anchors using polymers in drilled holes can also be used.

### Pressure injection of epoxy

If the cracks are reasonably small (opening width = 0.075 cm), the technique to restore the original tensile strength of the cracked element is pressure injection of epoxy [see Fig. 26.30(a)]. The procedure is as follows. The external surfaces are cleaned of non-structural materials and plastic injection ports are placed along the cracks on both sides of the member and secured in place with an epoxy sealant. The centre-to-centre spacing of these ports may be approximately equal to the thickness of the element. After the sealant has cured, a low-viscosity epoxy resin is injected into one port at a time, beginning at the lowest port of the crack in case it is vertical or at one end of the crack in case the crack is horizontal.

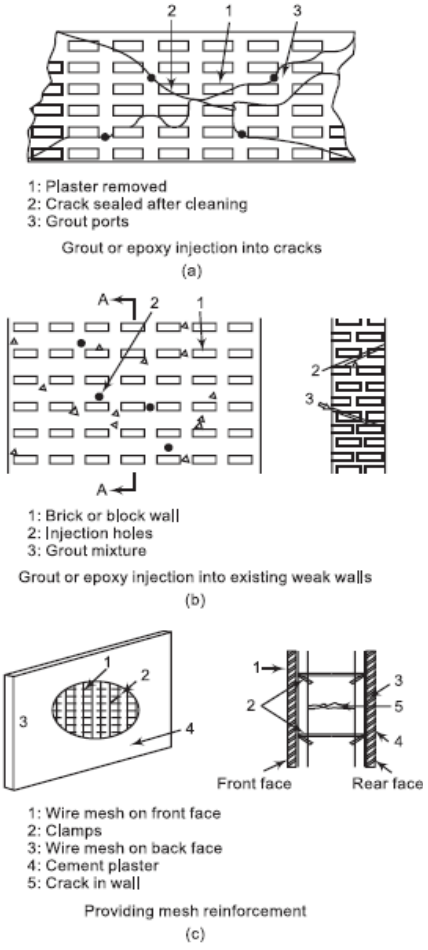



Fig. 26.30 Strengthening of existing masonry

The smaller the crack, the higher the pressure or more closely spaced the ports so as to obtain complete penetration of the epoxy material throughout the depth and width of the crack. Larger cracks will permit larger port spacing depending upon the width of the member. This technique is the appropriate for all types of structural element—beams, columns, walls, and floor units—in masonry as well as concrete structures.

### Large cracks and crushed concrete

For cracks wider than about 6 mm or for regions in which the concrete or masonry has crushed, a treatment other than injection is needed. The following procedure is adopted.

(a) The loose material is removed and replaced with any of the materials mentioned earlier, i.e., expansive cement mortar, quick-setting cement, or gypsum cement mortar [Fig. 26.30(b)].
(b) Wherever necessary, additional shear or flexural reinforcement could be added and covered by mortar to provide further strength as well as protection to the reinforcement.
(c) In areas of very severe damage, the member or a portion of the member can be replaced.
(d) In the case of damage to walls and floor diaphragms, a steel mesh could be provided on the outside surface and nailed or bolted to the wall. Then it may be covered with plaster or micro-concrete [Fig. 26.30(c)].

Fractured, excessively yielded, and buckled reinforcement

In the case of severely damaged reinforced concrete members, it is possible that the reinforcement would have buckled or elongated, or excessive yielding may have occurred. Replacing the old portion of steel with new steel using butt welding or lap welding can repair such an element.

If the structure has to be repaired without removing the existing steel, the best approach would be, depending upon the space available in the damaged portion before concreting, to confine the concrete and enclose the longitudinal bars to prevent their buckling in future.

In some cases it may be necessary to anchor additional steel into the existing concrete. A hole larger than the bar is drilled. The hole is filled with epoxy, expanding cement, or any other high-strength grouting material. The bar is pushed into place and held there until the grout has set. This will anchor the steel that is being added longitudinally.

### Fractured wooden members and joints

Since wood is an easily workable material, it is easy to restore the strength of wooden members, in beam–column structures, and ties by splicing additional material. It is advisable to use steel straps to cover all such splices and joints so as to keep them tight and stiff.

### 26.4.5 Modification of Roofs

(a) Roofing tiles are brittle and get dislodged easily. Wherever possible they should be replaced with corrugated iron sheeting.
(b) False ceilings of brittle material are dangerous. Non-brittle material such as Hessian cloth, bamboo matting, or light foam substances may be used for false ceilings.
(c) Welding or clamping suitable diagonal bracing members in the vertical as well as horizontal planes can be used to brace roof trusses and frames.
(d) Anchors of roof trusses to supporting walls can be improved.
(e) Wherever the roof or floor consists of prefabricated units such as RC rectangular, T, or channel units or wooden poles and joists carrying brick tiles, the integration of such units is necessary. Timber elements could be connected to diagonal planks nailed to them and spiked to an all round wooden frame at the ends. RC elements may have either a 40-mm cast-in-situ-concrete topping with a 6-mm-diameter bar 150 mm c/c both ways or a horizontal cast-in-situ RC ring beam all round into which the ends of the RC elements are embedded (Fig. 26.31 shows the details).
(f) Roofs or floors consisting of steel joists and flat or segmental arches must have horizontal ties holding the joists horizontally in each arch span so as to prevent the spreading of joists. If such ties do not exist, these could be installed by welding or clamping.

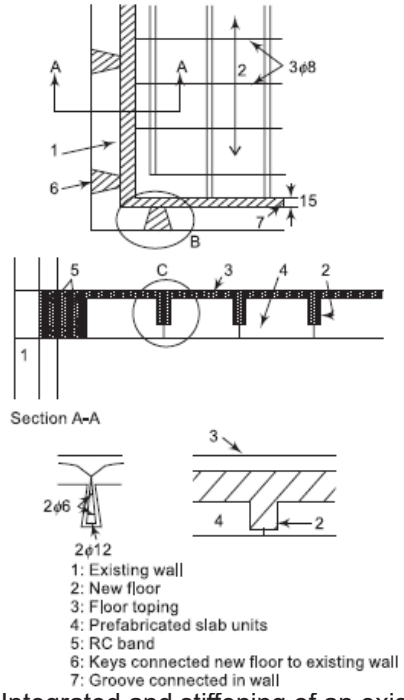



Fig. 26.31 Integrated and stiffening of an existing floor

### 26.4.6 Substitution or Strengthening of Slabs

Insertion of a new slab: A rigid slab inserted into the existing walls plays an important role in the resisting mechanism of the building in keeping the walls together and distributing seismic forces among the walls. The slab has to be properly connected to the walls through an appropriate key arrangement as shown in Fig. 26.32.

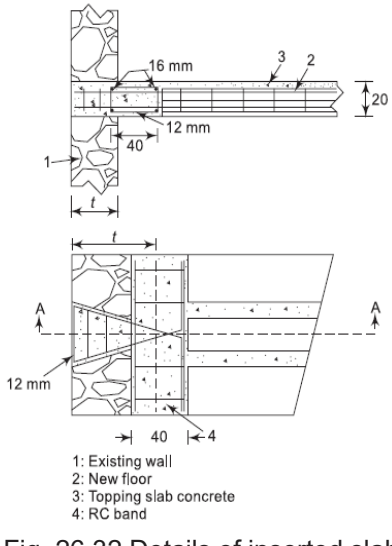



Fig. 26.32 Details of inserted slab

### 26.4.7 Modification and Strengthening of Walls

**Inserting new walls**

In case the existing building shows asymmetry, which may produce dangerous torsional effects during earthquakes, the centres of mass can be made coincident with the centre of stiffness by separating parts of the building, thus achieving individual symmetric units and/ or inserting new vertical resisting elements such as new masonry or reinforced concrete walls either internally as shear walls or externally as buttresses. The insertion of a cross wall is necessary for providing transverse supports to the longitudinal walls of long barracks-type buildings used for various purposes such as schools and dormitories. The main problem in such a modification is the connection of the new wall with the old wall, Fig. 26.33 shows an example.

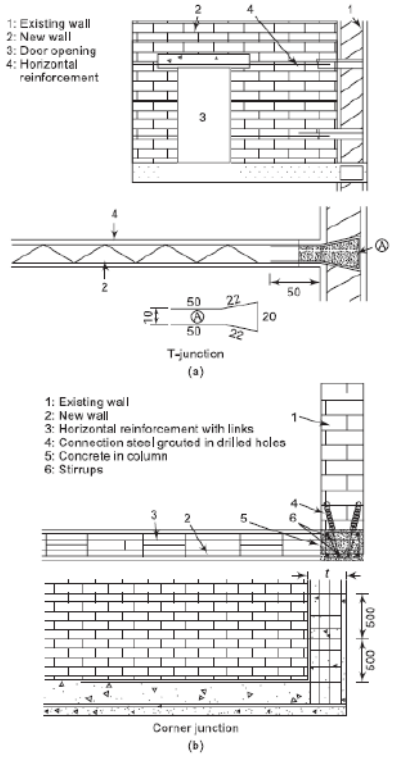



Fig. 26.33 Connection of new and old brick walls

**Strengthening existing walls**

The lateral strength of buildings can be improved by increasing the strength and stiffness of the existing individual walls, whether they are cracked or uncracked. This can be achieved (a) by grouting, (b) by adding vertical reinforced concrete coverings on the two sides of the wall, and (c) by prestressing the walls.

Grouting A number of holes are drilled into the wall (two to four per m2). First, water is injected in order to wash the wall inside and improve the cohesion between the grout mixture and the wall elements. Second, a cement–water mixture (1:1) is injection grouted at low pressure (0.1–0.25 MPa) in the holes, starting from the lower holes and going up. Alternatively, polymeric mortars may be used for grouting. The increase of shear strength that can be achieved this way is considerable.

Strengthening with wire mesh Two steel meshes (welded wire fabric with a mesh size of approximately 50 × 50 mm) are placed on the two sides of the wall; they are connected by passing steel (each 500–750 mm apart); see Fig. 26.30. A 20–40 mm thick cement mortar or micro-concrete layer is then applied on the two sides. The two are clamped to form a network. This gives rise to two interconnected vertical plates. This system can also be used to improve the connection of orthogonal walls (Fig.26.34).

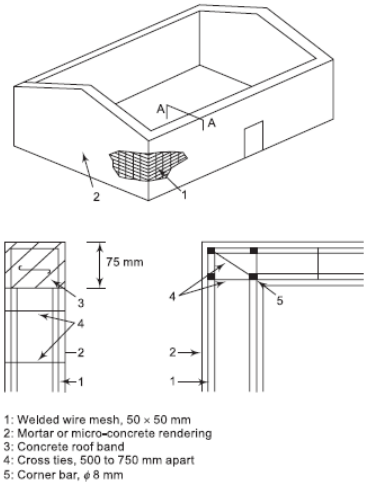



Fig. 26.34 Strengthening with wire mesh and mortar656 Concrete Technology

Connection between existing stone walls In stone buildings consisting of fully dressed stone masonry in good mortar, perpendicular walls can be effectively sewed by drilling inclined holes through them, inserting steel rods, and injecting cement grout (Fig. 26.35).

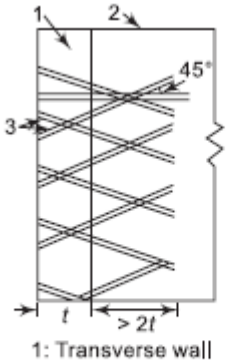
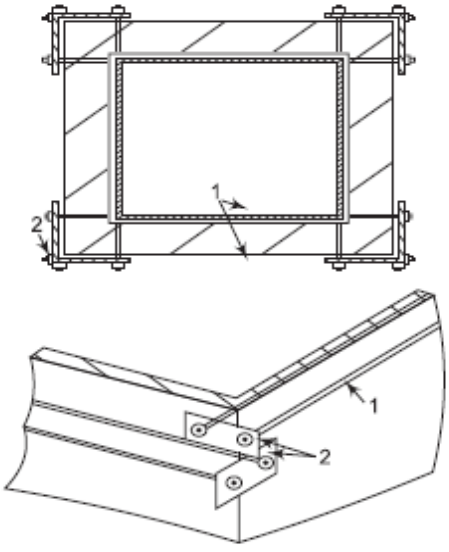



Fig. 2 l bars

**Prestressing**

A horizontal compression state induced by horizontal tendons can be used to increase the shear strength of walls. Moreover, this wall also improves considerably the connections of orthogonal walls (Fig. 26.36). The easiest way of effecting the pre-compression is to place two steel rods on the two sides of the wall and tensioning them using turnbuckles. Note that good effects can be obtained by slight horizontal prestressing (about 0.1 MPa) on the vertical section of the wall. Prestressing is also useful for strengthening the spandrel beam between two rows of openings in case no rigid slab exists.



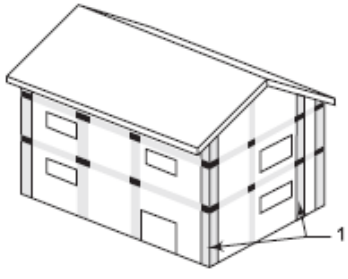

1: Steel rod for prestressing
2: Anchor plates

Fig. 26.36 Strengthening of wall by prestressing

### External binding

Opposite parallel walls can be held to internal cross walls by prestressing bars as explained above, the anchorage being done against horizontal steel channels instead of small steel plates. The steel channels running from one cross wall to the other will hold the walls together and improve the integral box-like action of the walls.

The technique of covering the wall with steel mesh and mortar or micro-concrete may be used only on the outside surface of external walls while maintaining continuity of steel at the corners. This would strengthen the walls as well as bind them together. As a variation and for economy in the use of materials, the covering may be in the form of vertical splints between openings and horizontal bandages over spandrel walls at a suitable number of points only (Fig. 26.37).




1: Wire mesh with width ≥ 400 mm

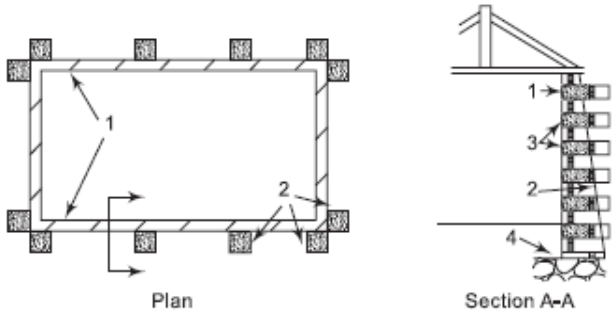
Fig. 26.37 Splint and bandage strengthening technique

### Other strengthening measures

If the walls have large arched openings in them, it will be necessary to install tie rods across them at the springing level or slightly above it by drilling holes on both sides and grouting steel rods in them. Alternatively, a lintel consisting of steel channels or I-sections could be inserted just above the arch. In jack-arch roofs, flat iron bars or rods may be provided to connect the bottom flanges of I-beams, connected by bolting or welding.

Random-rubble masonry walls are most vulnerable to complete collapse and must be strengthened by internal impregnation by rich cement mortar grout in the ratio of 1:1 or better still covered with steel mesh and mortar. Damaged portions of the wall, if any, should be reconstructed using richer mortar.

For bracing the longitudinal walls of long barracks-type buildings, a portal-type framework can be inserted transverse to the walls and connected to them. Alternatively, masonry buttresses or pilasters may be added externally (Fig. 26.38).




1: Existing wall
2: Buttress or pilaster
3: Key stone
4: Foundation

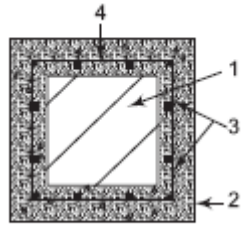
Fig. 26.38 Strengthening of long walls by buttresses

In framed buildings, the lateral resistance can be improved by inserting knee braces, full diagonal braces, or infill walls.

### 26.4.8 Strengthening RC Members

The strengthening of reinforced concrete members is a task that should be carried out by a structural engineer after suitable calculations. This section includes a few suggestions to illustrate the ways in which the members can be strengthened.

(a) RC columns can best be strengthened by jacketing and providing an additional cage of longitudinal and lateral tie reinforcement around the columns and casting a concrete jacket (Fig. 26.39). The desired strength and ductility can thus be built up.




1: Existing column section
2: Added section
3: New longitudinal bar
4: New tie bars

Fig. 26.39 Jacketing of concrete column

(b) A reinforced concrete beam can also be jacketed in the above-mentioned manner. For holding the stirrup in this case, holes will have to be drilled through the slab (Fig. 26.40) or through the web.

(c) A similar technique could be used for strengthening RC shear walls.

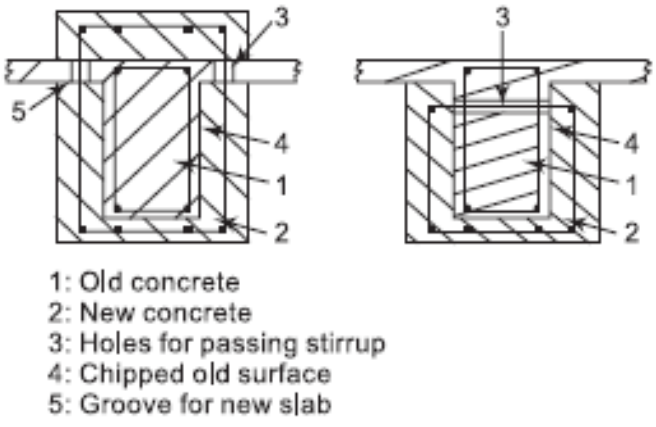



Fig. 26.40 Increasing the section and reinforcing the existing beam

(d) An inadequate section of RC columns and beams can also be strengthened by removing the cover to the old steel, welding new steel to the old steel, or replacing it. In all cases of adding new concrete to old concrete, the original surface should be roughened and grooves made in the appropriate direction for providing shear transfer. The ends of the additional steel must be anchored in the adjacent beams or columns as the case may be. Old concrete can be effectively bonded to new concrete using polymer bonding agents.

### 26.4.9 Strengthening Foundations

Seismic strengthening of foundations before or after an earthquake is the most involved task since it may require careful underpinning operations. Some alternatives are given below for the preliminary consideration of the strengthening scheme.

(a) Introducing new load-bearing members including foundations to relieve the already loaded members. Jacking operations may be needed in this process.

(b) Improving the drainage of the area to prevent saturation of the foundation soil to obviate any problems of liquefaction, which may occur because of poor drainage.

(c) Providing an apron around the building to prevent the soaking of the foundation directly and draining off of the water.

(d) Adding strong elements in the form of reinforced concrete strips attached to the existing foundation. These will also bind the various wall footings and may be provided on both sides of the wall. To avoid digging the floor inside the building, the extra width could be provided only on the outside of the external walls. The extra width may be provided over the existing footing at the level of the existing footing. In any case, the reinforced concrete strips and the walls have to be linked by a number of keys inserted into the existing footing (Fig. 26.41). To avoid disturbing the integrity of the existing wall during the foundation strengthening process, proper investigation and design is called for.

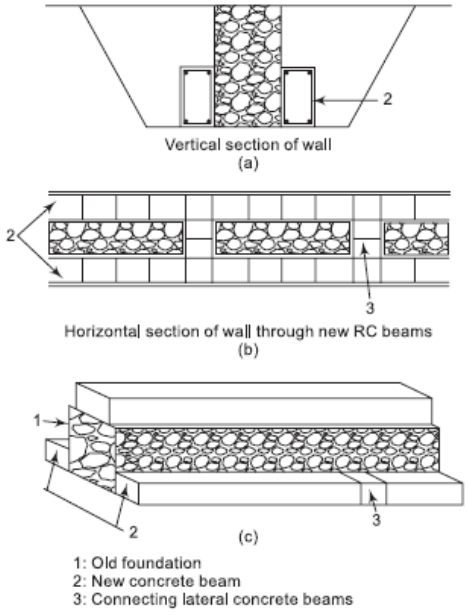



Fig. 26.41 Improving a foundation by inserting lateral concrete beams

Various types of natural disasters such as earthquakes and cyclones have been identified and discussed in detail in this chapter. The philosophy of disaster-resistant design has been explained. The various aspects of planning and construction of buildings that should be adopted to make the structure disaster resistant have been illustrated. Both load-bearing and framed structures have been considered. Buildings have been categorized based on their multi-hazard-resisting capabilities. The importance of anchorage, bracing, and continuity has been highlighted. The differences among repair, retrofit, and rehabilitation have been enumerated. The methods for repairing and retrofitting typical existing structures have been included. This chapter will enable the reader to appreciate the current state of knowledge for making structures safe, durable, and economical.

### Review Questions

1. What is the aim of disaster-resistant construction?
2. How are coastal zones defined?
3. List the various disasters that affect structural stability.
4. What are the effects of earthquakes on buildings?
5. What are the aerofoil effects of wind on structures?
6. What do you understand by multi-hazard risk and how are buildings classified to provide resistance to multi-hazards?
7. What are the methods to introduce disaster resistance in masonry buildings?
8. Describe the importance of detailing of reinforcements in introducing disaster resistance in RCC framed constructions.
9. Describe the importance of joint detailing?
10. Distinguish among repair, restoration, and rehabilitation.
11. What are the various methods of rehabilitation for seismic strengthening?
12. Give an example of foundation strengthening for increasing seismic resistance.

## Appendix 26.1
## Categories of Earthquake Damage

| Damage category | Extent of damage (in general) | Suggested post-disaster action |
|---|---|---|
| No damage | No damage | No action required |
| Slight non-structural damage | Thin cracks in plaster and falling of small plaster bits | Building need not be vacated. Only architectural repairs needed. |
| Slight structural damage | Small cracks in walls, falling of large pieces of plaster over large areas; damage to non-structural parts such as chimneys and projecting cornices. The load-carrying capacity of the structure is not reduced appreciably | Building need not be vacated. Architectural and other minor repairs required to achieve durability |
| Moderate structural dam | Large and deep cracks in walls; widespread cracking of walls, columns, and piers and titling or falling of chimneys. The load-carrying capacity of the structure is partially reduced. | Building needs to be vacated. It can be reoccupied after restoration and strengthe-ning. Structural restoration and strengthening are necess-ary, after which architectural treatment may be carried out. |
| Several structural damage | Gaps occur in walls; inner and outer walls collapse; failure of ties separating parts of buildings. Approximately 50% of the main structural in a dangerous state. | Building has to be vacated. Either the building has to be demolished or extensive restoration and strengthening work has to be carried out before reoccupation. The building may also be temporarily shored and supported for safety. |
| Collapse | A large part of or the entire building collapses | The site needs to be cleared and the building reconstruc-ted. |

## Appendix 26.2
## Building Categories for Various Multi-hazard Resisting Features

In this appendix, it is intended to cover specified features of design and construction for multi-hazard resistance of conventional buildings. In cases of other special buildings, a detailed analysis of earthquake/wind forces will be necessary.

For the purpose of specifying the earthquake-resisting features in conventional buildings, buildings have been categorized into four types based on the multi-hazard forces they are intended to resist, as shown in the following table.

**Building categories for various multi-hazard resisting features**

| Building category | Soil type | Seismic zone | Wind zone (basic wind speed) | Importance factor |
|---|---|---|---|---|
| IV | Type I | II | $V_b$ £ 33 m/s | 1 |
| III | Type III | III | 34 ≥ $V_b$ ≥ 39 m/s | 1 |
| II | Type IV | IV | 40 ≥ $V_b$ ≥ 49 m/s | 1.5 |
| I | Type V | V | $V_b$ ≥ 50 m/s | 1.5 |

The building categories can be of four types. Type I is the most vulnerable. Vulnerability goes on decreasing from type I to type IV, making type IV least vulnerable. To fix the building category one has to have data with respect to soil type, seismic zone, wind zone, importance factor of the building that is under scrutiny. The building category is fixed based on each requirement first. For example, let us take a building situated in soil type I, seismic zone IV, wind zone V6 ≥ 50 m/s and having an importance factor of 1. As per the table, the following categories are possible

| | |
|---|---|
| Soil type I | Building category IV |
| Seismic zone IV | Building category III |
| Wind zone V6 ≥ 50 m/sec | Building category I |
| Importance factor = 1 | Building category III |

The most valuable category of the above = I is chosen as building category.

## Appendix 26.3
## Information on and Classification of Coastal Regulation Zones

For regulating development activities, the coastal stretches within 500 m of the high-tide line on the landward side are classified into four categories, as described in the following.

### Category I (CRZ I)

1. Areas that are ecologically sensitive and important, such as national parks/marine parks, sanctuaries, reserve forests, wildlife habitats, mangroves, corals/coral reefs, areas close to breeding and spawning grounds of fish and other marine life, areas of outstanding natural beauty/historic/heritage areas, areas rich in genetic diversity, areas likely to be inundated due to rise in sea level consequent to global warming, and other such areas that may be declared by the Central Government or the concerned authorities at the State/Union Territory level from time to time.
2. Areas between the low-tide and high-tide lines.

### Category II (CRZ II)

1. The areas that have already been developed up to or close to the shoreline. For this purpose, 'developed area' refers to an area within the municipal limits or other legally designated urban areas which are already substantially built up and have been provided with drainage and approach roads and other infrastructural facilities, such as water supply and sewerage mains.

### Category III (CRZ III)

1. Areas that are relatively undisturbed and those which do not belong to category I or II. These will include coastal zones in rural areas (developed and undeveloped) and also areas within municipal limits or other legally designated urban areas which are not substantially built up.

### Category IV (CRZ IV)

1. Coastal stretches in Andaman and Nicobar, Lakshadweep, and other small islands, except those designated CRZ I, CRZ II, or CRZ III.

## Appendix 26.4

## MSK Intensity Scale

The following definitions are used in the scale.

Types of structures (buildings)

| | |
|---|---|
| Structure A | Buildings of fieldstone, rural structures, unburnt brick houses, clay houses |
| Structure B | Ordinary brick buildings, buildings of the large block and prefabricated type, half-timbered structures, buildings in natural hewn stone |
| Structure C | Reinforced buildings, well-built wooden structures |

### Definition of quantity

| | |
|---|---|
| Single, few | About 5% |
| Many | About 50% |
| Most | About 75% |

### Classification of damaged buildings

| | |
|---|---|
| Grade 1: Slight damage | Fine cracks in plaster; falling of small pieces of plaster |
| Grade 2: Moderate damage | Small cracks in walls; falling of fairly large pieces of plaster, slipping off of pantiles; cracks in chimneys; falling of parts of chimneys. |
| Grade 3: Heavy damage | Large and deep cracks in walls; falling of chimneys |
| Grade 4: Destruction | Gaps in walls; probable collapse of parts of buildings; separate parts of the building lose their cohesion; collapse of inner walls. |
| Grade 5: Total damage | Total collapse of buildings |

### Intensity Scale

I. Not noticeable
II. Scarcely noticeable (very slight)
III. Weak, partially observed only
IV. Largely observed
V. Strong
VI. Slight damage

Damage of grade 1 is sustained in single buildings of type B and in many of type A. Damage in few buildings of type A is of grade 2.

VII. Damage to buildings In many buildings of type C damage of grade 1 is caused; in many buildings of type B damage is of grade 2. Most buildings of type A suffer damage of grade 3, few suffer damage of grade 4. In certain instances, landslips of roadway on steep slopes; cracks in roads; seams of pipelines damaged; cracks in stone walls.

VIII. Destruction of buildings Most buildings of type C suffer damage of Grade 2 and few suffer damage of grade 3, most buildings of type B suffer damage of grade 3, and most buildings of type A suffer damage of grade 4. Many buildings of type C suffer damage of grade 4. Occasional breaking of pipe seams; memorials and monuments move and twist; tombstones overturn; stone walls collapse.

IX. General damage to buildings Many buildings of type C suffer damage of grade 3 and a few suffer damage of grade 4; many buildings of type B show damage of grade 4 and a few show damage of grade 5. Many buildings of type A suffer damage of Grade 5. Monuments and columns falls; considerable damage to reservoirs; underground pipes partly break. In individual cases railway lines are bent and roadways damaged.

X. General destruction of buildings Many buildings of type C suffer damage of grade 4 and a few suffer damage of grade 5. Many buildings of type B show damage of grade 5; most of type A show destruction of grade 5. Critical damage to dams and dykes and severe damage to bridges; railway lines are bent; road paving and asphalt show waves.

XI. Catastrophe Severe damages even to well-built buildings, bridges, dams, and railway lines; highways become useless; underground pipes get destroyed.
XII. Landscape changes Practically all structures above and below ground are greatly damaged or destroyed.

## Appendix 26.5
## Design Procedure for Wind Resistance in Buildings

The following procedure may be followed to design a building that will be resistant to damages during high winds/cyclones.

### Fixing the design data

(a) Identify the national wind zone in which the building is situated. This can be done using the wind code [IS: 875(3)–1987] or the Vulnerability Atlas of India (1997).
(b) Corresponding to the zone, fix the basic design wind speed Vb, which can be treated as constant up to the height of 10 m.
(c) Choose the risk coefficient or the importance factor k1 for the building from the values given below:

| Building type | Coefficient $k_1$ |
|---|---|
| Ordinary residential building | 1.0 |
| Important building (e.g., hospital, police station, telecommunication building, school, community and religious buildings, and cyclone shelters) | 1.08 |

(d) Choose appropriate value of k2 corresponding to the building height, type of terrain, and size of building structure, as per IS: 875(3)–1987. For buildings up to 10 m height and belonging to category A, which covers the majority of housing, the values are as follows.

| Terrain | Coefficient $k_2$ |
|---|---|
| Flat coastal area | 1.05 |
| Level open ground | 1.00 |
| Built-up suburban area | 0.91 |
| Built-up city area | 0.80 |

(e) The factor k3 depends upon the topography of the area and its location above sea level. It accounts for the acceleration of wind near crests of cliffs or along ridge lines and deceleration in valleys, etc.

### Determining the wind forces

(a) Determine the design wind velocity Vz and normal design pressure $p_z$

$$V_z = V_b K_1 K_2 K_3$$

$$p_z = 0.0006 V_z$$

$p_z$ Will be in kN/m$^2$ for $V_z$ in m/s

(b) Corresponding to the building dimensions (length, height, width) and the shape in the plan and elevation, the roof type and its slopes as well as projections beyond the walls determine the coefficients for the loads on all walls, roofs, and projections, taking into consideration the internal pressures based on the size and location of the openings. Hence calculate the wind loads on the various elements normal to their surface.
(c) Decide on the line of resistance, which will indicate the bracing requirements in the planes of the roof slopes, at the eave level in the horizontal plane, and in the plane of the walls. Then determine the loads generated on the following connections:

- roof cladding to purlins
- purlins to rafters/trusses
- rafters/trusses to wall elements
- between long and cross walls
- walls to footings

### Designing the elements

The load effect is determined by considering all the critical combinations of dead, live, and wind load in the design of elements; stress reversal under wind suction should be given due consideration. Members such as flanges, which are usually in tension under dead and live loads, may be subjected to compression under dead load and wind, requiring the consideration of buckling in their design.

(a) Load effect is determined by considering all the critical combinations of dead, live, and wind load in the design of elements; stress reversal under wind suction should be given due consideration. Members such as flanges, which are usually in tension under dead and live loads, may be subjected to compression under dead load and wind, requiring consideration of buckling in their design.
(b) Even thin reinforced concrete slabs, say, 75 mm thick, may be subjected to uplift under wind speeds of 55 m/s and higher, requiring holding down by anchors at the edges and reinforcement on the top face! As a guide there should be extra dead load (insulation, weathering course, etc.). On such roofs, the aim should be to increase the effective weights to about 375 kg/m2.
(c) Resistance to corrosion is a definite requirement in cyclone-prone coastal areas. The steel structures may be painted with corrosion-resistant paints. In reinforced concrete construction, a mix of M20 grade with increased cover to the reinforcement has to be adopted. Low water–cement ratio with densification by means of vibrators will minimize corrosion.
(d) All dynamically sensitive structures such as chimney stacks, specially shapes water tanks, and transmission line towers should be designed following the dynamic design procedures given in various IS codes.
(e) The minimum dimensions of electrical poles and their foundations can be chosen to achieve their fundamental frequency above 1.25 Hz so as to avoid large-amplitude vibrations and consequent structural failure.

### Conclusion

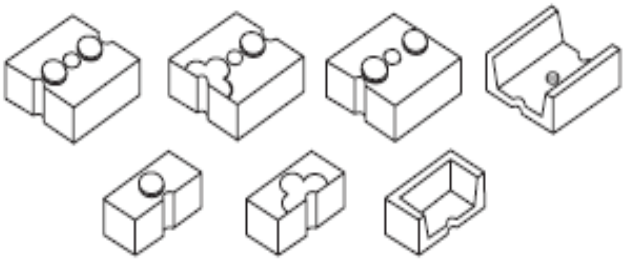
It may be emphasized that good quality design and construction is the single factor ensuring safety as well

as durability in cyclone-prone areas. Hence all building materials and techniques must follow the applicable Indian Standard Specification.

## Appendix 26.6
## Basic Design for Compressed Stabilized Earth Block

### Principle

Compressed stabilized earth block (CSEB) is a sound technology prompted by Auroville Earth Institute, Pondichery. Figure A26.1 shows the various types of blocks that can be produced by the Auram machine using local labour.



### General principles for a good design

A well-designed building should have 'good boots and a good hat'. That means a good basement (minimum 25 cm high, see Fig. A26.2) good overhangs (minimum 25 cm wide or better 50 cm, see Fig. A26.2)

Compressive strength for earthquake-resistant CSEB

(a) Design the walls (thickness + stability) according to the weight-bearing capacity of wet CSEB.

(b) The minimum admissible crushing load of the CSEB should be 25 kg/cm2 under wet conditions (after 3 days immersion).

(c) Keep at least a safety factor of 10 from the wet crushing strength (σc) for CSEB.

Example: An CSEB has a wet σc of 25 kg/cm2; the maximum load bearing for the basement will be 25/10 = 2.5 kg/cm2

### Shear strength

Avoid any major difference of load bearing in CSEB walls, especially with a different floor height (see Fig. A26.3).

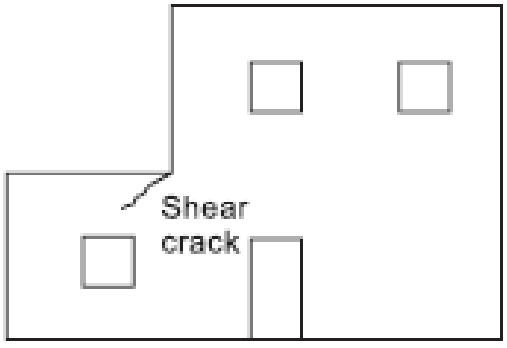



Fig. A26.3 Shear crack in a building with different floor height

### Water absorption and erosion

(a) Avoid any concentration or accumulation of water in any part or surrounding of the building.

(b) Avoid any transport of water (i.e., leakage) in a any part of the building.

### Module of blocks

Design the building according to the module of blocks. The module of the block is its nominal size plus the mortar thickness.

### Reference

The CSEB technology is promoted by Auroville Earth Institute (AEI), and the information in this appendix is based on a publication of AEI.

## Appendix 26.7
## List of IS Codes Published by the Bureau of Indian Standards

IS: 1893-2002 Criteria for Earthquake Resistance Design of Structures, Part 1: General Provision and Buildings.

IS: 4326-1993 Earthquake Resistance Design and Construction of Buildings— Code of Practice.

IS: 13827-1993 Improving Earthquake Resistance of Earthen Buildings— Guidelines.

IS: 13828-1993 Improving Earthquake Resistance of Low Strength Masonry Buildings—Guidelines.

IS: 13920-1993 Ductility Detailing of Reinforced Concrete Structures Subjected to Seismic Forces—Code of Practice.

IS: 13935-1993 Repair and Seismic Strengthening of Buildings—Guidelines. IS: 456-2000 Code of Practice for plain and Reinforced Concrete—Code of Practice.

IS: 800-1984 Code of Practice for General Construction in Steel (reprint: 1999). IS: 6922-1973 Criteria for Safety and Design of Structures subject to Underground Blasts

IS: 4991-1968 Criteria for Blast Resistance Design of Structures for Explosions above ground

IS: 4967-1968 Recommendations for seismic Instrumentation for River Valley Projects

IS: 15498-2004 "Guidelines for improving the cyclonic resistance of low rise houses and other buildings/ structures

IS: 15499-2004 "Guidlines for survey of housing and building topology in cyclone prone areas for assessment of vulnerability of regions and past cyclone damage estimation

IS: 14496-1998 Guideline for preparation of level slide—Hazard zonation maps in mountainous terrain: Part 2: Macro zonation

IS: 14680-1999 Guidelines for landslide control

## 09.10.2021 மூன்றாவது மாநில அளவிலான மேலாண்மை மற்றும் பொதுக்குழு கூட்டம்


*12.10.2021 அன்று நடைபெற்ற டெங்கு தடுப்பு குறித்த விழிப்புணர்வு கூட்டம்*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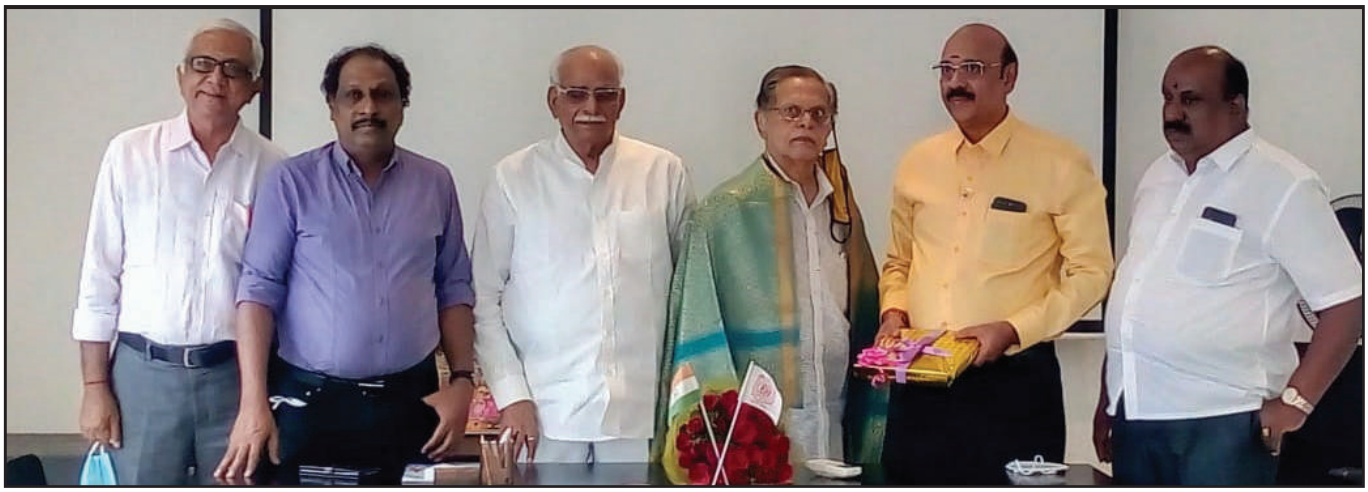

*28.10.2021 அன்று இணைப்புச்சங்கங்களின் (Affiliated) கலந்தாலோசனைக் கூட்டம் நடைபெற்றது.*

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## 30.10.2021 அகில இந்தியத்தலைவர் திரு. R. N. குப்தா மற்றும் தலைமையக நிர்வாகிகளோடு 30வது அகில இந்திய கட்டுநர் மாநாடு பற்றிய சிறப்புக்கூட்டம் நடைபெற்றது

# PROPERTIES OF BITUMEN AND ITS USE IN ROAD CONSTRUCTION

DR. Colonel.
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Introduction

Materials that are bound together with bitumen are called bituminous materials. The use of bituminous materials was initially limited to road construction. Now the applications have spread over the area of roof construction, industrial purposes, carpet tiles, paints and as a special coating for waterproofing. Bitumen density is 1040 kg/ m3, melt at 115°C, boil at 525°C and asphalt density is 2320 kg/m3.

History of Bituminous Materials. Before the era of bitumen, tar was used as the binder material for binding the materials. After the 20th century, new types of vehicles with pneumatic tires came into its existence. That time, the tar was used in road construction in larger areas. The road was constructed using water-bound and graded aggregates as per the principles that were developed by Macadam. Macadam roads produced a large amount of dust due to the action of the pneumatic tires and the speed of the vehicles moving is limited. This led to binding the surface of the road with this tar. Tar act as a dressing to coat the road surface. It is well suited for the purpose as it can be made semi-fluid and sprayed suitably. This cooling will get stiffened and protects the road from water attacks as well as bear the vehicle loads adequately.

Difference Between Bitumen and Tar. Tar is a sticky black liquid made of thick oil. It is a natural substance, oozing out of the ground. Most tar is produced from coal as a byproduct of coke production, but it can also be produced from petroleum, peat or wood. When compared to tar, bitumen is less temperature susceptible. So, for a given temperature, the bitumen has larger stiffness compared to the tar at the same temperature. This proved higher deformation resistance and softening resistance compared to the tar. In future, under high abrasion forces, they behave more brittle and highly crack resistant. Over the time, the number of vehicles go high so the traffic also increase. Hence it was essential to bring roads with increasing performance. This lead to the complete use of bitumen than tar.

Difference Between Bitumen and Asphalt. Bitumen is the liquid binder that holds asphalt together. The term bitumen is often mistakenly used to describe asphalt. A bitumen-sealed road has a layer of bitumen sprayed and then covered with an aggregate. This is then repeated to give a two-coat seal. Asphalt is a mixture of the dark bituminous pitch with sand or gravel, used for surfacing roads, flooring, roofing, etc. Asphalt is produced in a plant that heats, dries and mixes aggregate, bitumen and sand into a composite mix. It is then applied through a paving machine on site as a solid material at a nominated or required thickness, relative to the end-user. Asphalt results in a smoother and more durable asphalt road surface than a bitumen-sealed road. While bitumen is mostly used in a mixture, it can also be used as a binder for roads. Bitumen road is a layer of bitumen that is used in the road to adhere or seal other layers. Based on the position and the function of the material, the nature of the material also varies. The surface course, the binder as well as the base may be of asphalt. But the type and the properties of asphalt in each of these layers vary based on the location and the function. The asphalt in the surface course is different when compared with the asphalt that is used in the binder course or in the base.

Different Types of Bitumen

The main variation is brought by the change in the bitumen content, the bitumen grade, the aggregate type used and the size of the aggregates. The first one is "asphalt" and the second one is "macadam". Asphalts are bitumen mixture whose strength and stiffness is gained through the mortar property. While in the case of macadam, the strength is dependent on the aggregates that are used in the mix. For each case mentioned, the property of the bitumen change. It is found that the asphalt properties are more governed by the bitumen properties than in the case of macadam.

There are different types of bitumen available with different properties, specifications and uses

based on the requirements of the consuming industry. Bitumen is classified by the depth to which a standard needle will penetrate under specified test conditions. This “pen” test classification is used to indicate the hardness of bitumen, lower penetration values indicating a harder bitumen, higher values e.g. 160/220 indicate a softer grade. The specification of bitumen also shows variation with the safety, solubility, physical properties, and durability. To understand the performance of the bitumen when it is on service, the design of the physical properties of the material is highly essential. The bitumen can be classified as: Penetration Grade Bitumen, Oxidized Bitumen Grades, Cut Back Bitumen, Bitumen Emulsion, Polymer Modified Bitumen & Bituminous Concrete. IRC 29:1988-Specification for Bituminous Concrete. IS 73-2013: Specification for Paving Bitumen.

Penetration Grade Bitumen. Penetration test, which is conducted at a temperature of 25°C, and 60/70 penetration grade bitumen is widely used. When the needle sinks 6 to 7 mm in the bitumen, and this type of bitumen is called 60/70 bitumen. The penetration is measured in mm and it indicates the relative hardness of the bitumen. The penetration grade bitumen is refinery bitumen that is manufactured at different viscosities. The penetration test is carried out to characterize the bitumen, based on the hardness. Thus, it has the name penetration bitumen. The penetration bitumen grades range from 15 to 450 for road bitumen. But the most commonly used range is 25 to 200.

Oxidized Bitumen. The refinery bitumen is further treated by the introduction of processed air to get oxidized bitumen. By maintaining a controlled temperature, the air is introduced under pressure into soft bitumen. Compounds of higher molecular weight are formed by the reaction of these introduced oxygen and bitumen components. Thus, the Asphaltenes and the Maltenes content increases resulting in a harder mix. This harder mix has a lower ductility and temperature susceptibility. The oxidized bitumen is used in industrial applications such as roofing and coating for pipes.

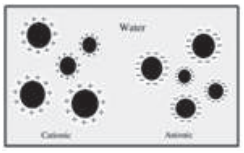
Penetration Grade

Oxidized

Cutback

Bitumen Emulsion

Polymer - Modified




Cationic and Anionic

Cutback Bitumen. This penetration grade bitumen of thermoplastic material has a temporarily reduced viscosity by adding a volatile oil having different viscosity for different temperatures. The volatile material is evaporated and bitumen gain its original viscosity. It is regaining back to its original hardness and property after setting. But when it is necessary to have fluidity at lower temperatures during surface dressing, cutback bitumen is employed. The time for curing and the viscosity of cutback bitumen can be varied and controlled by the dilution of volatile oil. 70/100 or 160/220 pen bitumen that is diluted with kerosene are the main compositions of bitumen in the construction of roads.

Bitumen Emulsion. This bitumen forms a two-phase system with two immiscible liquids. One of them is dispersed as fine globules within the other liquid. When discrete globules of bitumen are dispersed in a continuous form of water, bitumen emulsion is formed. This is a form of penetration grade bitumen that is mixed and used for laying purposes. An emulsifier having a long hydrocarbon chain with either a cationic or anionic ending is used for dispersing the bitumen globules. This emulsifier provides an electrochemical environment. The ionic part of the chain has an affinity towards the water and the bitumen is attracted by the hydrocarbon part. The hydrocarbon binds the bitumen globules strongly and the ionic part is seen on the surface of the globules. Depending on the ions present, the droplets take a charge. The emulsions can be cationic (positive charge) or anionic (negatively charged). The globules of the same charge hence repel each other, making the whole system stable. To facilitate adhesion with the aggregates (that are

negatively charged), cationic emulsions are more preferred. The stability of emulsions is dependent on: Types of bitumen emulsifier & its quantity, water evaporation rate, bitumen quantity, bitumen drop size and mechanical forces.

Polymer - Modified Bitumen. Polymer modified bitumen is the type of bitumen obtained by the modification of the strength and the rheological properties of the penetration graded bitumen, 2% to 8% of polymer is added. The polymer used can be either plastic or rubber. These polymers vary the strength and the viscoelastic properties of the bitumen. This is achieved by: Elastic response increase, Improvement in cohesive property, Improvement in Fracture strength and Providing ductility. Rubber polymers used are styrene block copolymers, synthetic rubbers, natural and recycled rubbers. Thermoplastic polymers plastics are also used.

Bituminous Materials. Graded aggregate and bitumen are the compositions of bituminous material. There is a small proportion of air present in the same, which make the bituminous material a three-phase material. The whole property of the bituminous material is highly dependent on the individual properties of each phase and their respective mix proportions. The two solid phases i.e. the bitumen and the aggregate are different in nature. The aggregate is stiff and hard in nature. The bitumen is flexible and vary under temperature as they are soft. So, the whole performance of the material is greatly influenced by the bitumen proportion in the whole mix. The supply of bitumen can be carried out in a variety of ways based on whether the demand is for laying or is to facilitate some other performance. When the quality and the performance of the bituminous material is concerned, the aggregate constituent quality is also a primary factor. The filler is the fine component of the aggregates, that would pass through 63 microns. The graded aggregate mix might contain some quantity of fillers. But when it is not adequate, extra filler either in the form of Portland cement, or hydrated lime, or limestone dust is used.

Sources of Bitumen. The bitumen has mainly two sources, they are: Natural Bitumen and Refinery Bitumen.

Natural Bitumen or Natural Asphalts. The bitumen is obtained from petroleum naturally with the help of geological forces. They are found to seen intimately connected with the mineral aggregates and found deposited at bitumen impregnated rocks and bituminous sands that have only a few bitumens in percentage. The asphalt found from the lake is refined to a partial state by heating it to a temperature of 1600C. This is done in open skill to remove out the excess water, later the material is filtered, barrelled and transported. It is hard to use the material directly on the roads as it consists of 55% of bitumen, mineral matter of 35% and 10% of organic matter. After treatment is blended with refinery bitumen before use.

Refinery Bitumen. This bitumen is the residual material that is left behind after the crude oil fractional distillation process. The crudes from different countries vary based on their respective bitumen content. It is found that crudes from the Middle East and the North Sea have to undergo further processes even after distillation to get the final bitumen. These sources have a very small bitumen content. But crude from the Caribbean and around countries give the higher content of bitumen that can be extracted with great ease.

Manufactured Bitumen. The manufacturing of bitumen is a lengthy process which is represented briefly in the figure. The bitumen is a residual material, the final bitumen property will depend upon the extent of extraction, the viscosity, and the distillation process. The present refinery plant has the capability to extract bitumen more precisely as the required viscosity and consistency.

Various Lab Tests on Bitumen for Pavement Construction.

Various laboratory tests on bitumen are conducted to check the quality and different properties of bitumen for pavement construction. Bitumen is a black or brown mixture of hydrocarbons obtained by partial distillation of crude petroleum. Bitumen is insoluble in water. It composes 87% Carbon, 11% Hydrogen and 2% Oxygen by weight. It is obtained in a solid or semi-solid state, used as a surface course for roads, roof coverings etc.

Tests on Bitumen to Check Quality and Properties for Pavement. To ensure the quality of bitumen

several tests are performed which are: Ductility test, Flash and Fire point test, Float test, Loss on the heating test, Penetration test, Softening point test, Specific gravity test, Viscosity test and Water content test. List of IS Codes related to bitumen testing are: IS 1201-1220:1978 specifies methods for testing tar and bitumen. Penetration test- IS: 1203-1978, Ductility test- IS: 1208-1978, Softening point test- IS: 1205-1978, Specific gravity test- IS: 1202-1978, Viscosity test- IS: 1206-1978, Flash and Fire point test- IS: 1209-1978, Float test- IS: 1210-1978, Water content test- IS: 1211-1978, Loss on heating test - IS:1212-1978.

Ductility Tests on Bitumen. The property of bitumen that allows it to undergo deformation or elongation is called ductility of bitumen. The ductility of bitumen is measured by the distance in Cm, to which the bitumen sample will elongate before breaking when it is pulled by a standard specimen at a specified speed and temperature.

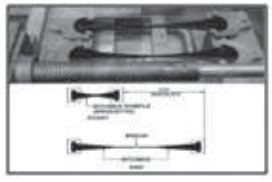
Flash and Fire Point Tests on Bitumen. Flashpoint of bitumen is defined as the point of the lowest temperature at which bitumen catches vapours of test flame and fires in the form of flash. The fire point of bitumen is defined as the point of the lowest temperature at which the bitumen ignites and burns at least for five seconds under specific conditions of the test. Flash and fire point test helps to control fire accidents in bitumen coated areas. By this test, we can decide the bitumen grade with respect to temperature for particular areas of high temperatures.

Float Tests on Bitumen. The float test is used to determine the consistency of bitumen. But generally use penetration test and viscosity test to find out the consistency of bitumen except for a certain range of consistencies.

Loss on Heating Tests on Bitumen. When the bitumen is heated, water content present in the bitumen is evaporated and bitumen becomes brittle which can be damaged easily. So, to know the amount of looseness we will perform this test. In this test, take the bitumen sample and note down its weight to 0.01gm accuracy at room temperature.

Penetration Test on Bitumen

The penetration value of bitumen is measured by distance in 1/10th of mm that a standard needle would penetrate vertically into the bitumen sample under standard conditions of the test. By this test, one can determine the hardness or softness value of bitumen.

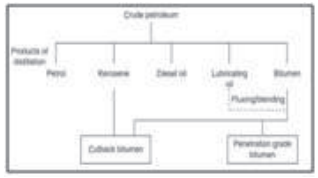


**Ductility Tests**

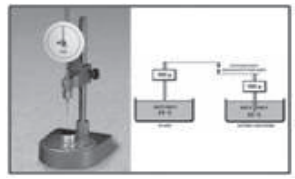
**Flash Tests**

**Float Tests**

**Heating Tests**

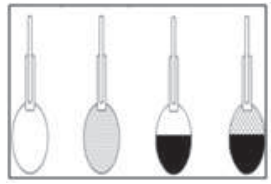


**Manufacturing**



**Penetration Test**

**Softening Point Test**



**Specific Gravity Test**

**Properties**

Softening Point Test on Bitumen. The softening point of bitumen indicates the point at which bitumen attains a particular degree of softening under specified conditions of the test. Take a small amount of bitumen sample and heat it up to 75 oC -100oC. Ring and ball apparatus is used to conduct this test. Heat the rings and apply glycerin to prevent them from sticking. Fill these rings with bitumen and remove the excess material with a hot sharp knife.

Specific Gravity Test on Bitumen. The specific gravity of bitumen is the ratio of the mass of a given volume of bitumen to the mass of an equal volume of water at a specified temperature. Specific gravity is a good indicator of the quality of the binder. Pycnometer method is used and its range is 0.97to 1. 02 based on grades.

Viscosity Test on Bitumen. Viscosity is the property of bitumen that influences the ability of bitumen to spread, penetrate the voids and also coat the aggregates. That is it influences the fluid property of bitumen. If the viscosity of bitumen is higher, the compactive effort of bitumen reduces and a heterogeneous mixture arises. If viscosity is lower, then it will lubricate the aggregate particles. Viscosity is determined by using a tar viscometer. The viscosity of bitumen is expressed in seconds is the time required for the 50 ml bitumen sample to pass through the orifice of a cup, under standard conditions of test and at a specified temperature.

Water Content Test on Bitumen. When bitumen is heated above the boiling point of water, sometimes the foaming of bitumen occurs. To prevent this bitumen should have minimum water content in it. Water content in bitumen is determined by the dean and stark method. In this method, the bitumen sample is kept in 500ml heat resistant glass container. The container is heated to just above the boiling point of water. The evaporated water is condensed and collected. This collected water is expressed in terms of the mass percentage of the sample. It should not be more than 0.2% by weight.

Requirements of Bitumen Mixes for Road Construction. Bitumen mix used in the construction of flexible pavement needs structural strength, surface drainage and surface friction.

Structural Strength of Bitumen Layer.

The hydrocarbons and their derivatives formed in a complex colloidal system will compose to form the bitumen structure. Bitumen is a colloidal system that dissolves in trichloroethylene. This solvent is used to determine the constituents that are present in the bitumen. The bitumen constituents can be subdivided as:

Asphaltenes: These are found to be insoluble in light aliphatic hydrocarbon solvents. Maltenes: These are soluble in n-heptane. The colloidal system of bitumen is a system with solid particles of Asphaltenes, that together form a cluster of molecules or these can be micelles; a continuum of Maltenes. Based on the micelles dispersion, the bitumen can either exist in the form of a Sol(Colloid particles) or the form of a Gel. Sol is formed when there is complete dispersal. The gel is formed when the micelles undergo flocculation to become flakes. The bitumen take a gel character when it has a higher quantity of saturated oil of molecular weightless. That bitumen with aromatic oils show sol character and it contains more in Asphaltenes.

Structural Bitumen composes of Bituminous surface or wearing course, Bituminous binder course and Bituminous base course. The primary purpose of these bitumen mixes is structural strength provision. This involves even load dispersion throughout the layers of the pavement. The loads involved are dynamic or static loads, which is transferred to the base sub-grade through the aggregate course. A granular base with a bituminous surface course is only provided for roads of low traffic. The rebounding effect of bitumen upper layers helps in having resistance against high dynamic effects due to the heavy traffic. Rebounding property is reflected by the stiffness and flexibility characteristics of the bitumen top layers. When looking from bottom to top, the flexibility characteristics should increase. The mix should make use of nominal maximum size aggregate, which must decrease from the base course- binder course - surface course.

Surface Drainage of Bituminous Pavements. Subsurface drainage can be facilitated using a granular sub-base in the construction of flexible pavement. Permeable asphalt treated base can be used to provide positive surface drainage in major highways. It behave as a separate course for facilitating subsurface drainage.

Surface Friction of Bituminous Roads. The pavement layer needs to provide enough skid resistance and friction, during vehicle passage, especially in wet conditions. This would ensure the safety of the passengers. The macro and the micro surface texture of the asphalt mix contributes towards the surface friction. The mix gradation i.e. open-graded or dense graded will contribute to macro surface texture. The open-graded mix has a higher macro surface than dense-graded. The water is squeezed out from the bottom of the vehicle tire when the high macro surface texture is implemented. The micro surface texture is contributed by the aggregate surface, which is exposed when the above bitumen layer is torn.

Reasons for Use of Bitumen in Flexible Road

Construction. The basis behind the significant application of bitumen in flexible pavements are:

Production of Bitumen is Economical. Bitumen is a by-product of the crude oil distillation process. Crude oil itself is a composition of hydrocarbons. When these fuels are refined from crude oil, the bitumen is left behind. Further treatment of by-product, to make it free from impurities give pure bitumen. This by-product is utilized as a new construction material, without going for any other new resource.

Physical and Rheological Properties of Bitumen Bring Versatility. The physical and the chemical properties of Bitumen are found to be a function of load level, temperature and the duration of loading. It is a thermoplastic and viscoelastic material. These dependencies make us truly access the traffic on the road so that bitumen mix properties can be varied based on the stress levels calculated. This versatility of bitumen results in a large variety of bitumen mix, based on the road application.

The Melting Point of Bitumen is Low. It is highly appreciable about the fact that bitumen has a favourable melting point, which helps in both surface dressing and wearing resistance with ease. The melting point of the bitumen should not be too high, that it can be melted easily during laying the pavement. At the same time, bitumen has a melting point, which would not let the already casted road pave to melt and deform under high temperatures. Melting point of Bitumen is 115°C and boiling at 525°C, 50°C is enough for melting in road.

Bitumen can Undergo Recycling. As the melting point of bitumen is favourable, it can be melted back to its original state. This is called as asphalt recycling process. The torn-up asphalt pieces are taken up to the recycling plant, instead of sending them to landfills. This recycled mix can be reused.

Bitumen Gain Adhesive Nature. As it is free from hydrocarbon and hence not toxic. The by-product is refined to the maximum to get rid of organic materials and impurities. The bitumen has a highly adhesive nature, which keeps the materials in the road mix bind together under strong bonds.

Bitumen has Colour Variety. The traditional bitumen is black. This is because the dense organic material within bitumen is black. Now, when certain pigments are added, to get the desired colour of our choice.

Influence of Bitumen Constituents in the Material Properties. The individual fractions that form a bitumen surely have some contribution towards the properties of the bitumen material. The Asphaltenes is the fraction that shapes the body for the material. The resin in the bitumen contributes to the adhesiveness and ductility of the material. The viscosity and the rheology of the material are taken care of by the oils present in the bitumen material. The stiffness of the material is governed by the sulfur that is present in significant amounts mainly in high molecular weighed fractions. The presence of a certain complex of oxygen will affect the acidity of the bitumen. The acidity of the bitumen is a factor whose determination will help in knowing the adhering capability of the bitumen with the aggregate particles.

Use of Bituminous Material in Flexible Pavement. The bituminous materials are mostly employed for the construction of flexible pavement. When the road construction makes use of concrete slabs, it is a rigid construction. The flexible pavement itself has several layers, each having specific functions to be carried out, under loads. A general flexible pavement layer in flexible pavement.

Steps in Bituminous Road Construction. Bitumen road construction consists of various steps such as preparation of base course, application of bituminous coat, placement of bituminous mix, rolling and check for quality etc. IS 3117.2004 specifies bitumen emulsion for roads specifications.

Preparation of the existing Base Course Layer. The existing surface is prepared by removing the potholes or rust if any. The irregularities are filled in with premix chippings at least a week before laying the surface course. If the existing pavement is extremely way, a bituminous levelling course of adequate thickness is provided to lay a bituminous concrete surface on a binder course instead of directly laying it on a WBM.

Application of Tuck Coat. It is desirable to lay an Asphalt Concrete layer over a bituminous base or binder course. A tack coat of bitumen is applied at 6.0 to 7.5 kg per 10 sq.m area, this quantity may be increased to 7.5 to 10 kg for the non-bituminous base.

Preparation and Placing of Premix. The premix is prepared in a hot mix plant of the required capacity with the desired quality control. The bitumen may be heated up to 150 oC to 177oC and the aggregate temperature should not differ by over 14oC from the binder temperature. The hot mixed material is collected from the mixture by the transporters, carried to the location is spread by a mechanical paver at a temperature of 121 oC to 163oC. The camber and the thickness of the layer are maintained. The control of the temperatures during the mixing and the compaction is of great significance in the strength of the resulting pavement structure.

Rolling. A mix after it is placed on the base course is thoroughly compacted by rolling at a speed not more than 5km per hour. The initial or break down rolling is done by 8 to 12 tonnes roller and the intermediate rolling is done with a fixed wheel pneumatic roller of 15 to 30 tonnes having a tyre pressure of 7kg per sq. cm. the wheels of the roller are kept damp with water. The number of passes required depends on the thickness of the layer. In warm weather rolling on the next day, helps to increase the density of the initial rolling was not adequate. The final rolling or finishing is done by an 8 to 10 tonne tandem roller.

Quality Control of Bituminous Concrete Construction. Bituminous concrete is a mixture of asphalt and graded aggregate widely used as paving material over a prepared base; normally placed, shaped, and compacted while hot, but can be prepared for placement without heat. Routine checks are carried out at the site to ensure the quality of the resulting pavement mixture and the pavement surface. Periodical checks are made for: (a) Aggregate grading. (b) Grade of bitumen. (c) Temperature of aggregated concrete. The temperature of paving mix during mixing and compaction. At least one sample for every 100 tonnes of the mix discharged by the hot mix plant is collected and tested for the above requirements. Marshall tests are also conducted for every 100 sq.m of the compacted surface, one test of the field density is conducted to check whether it is at least 95% of the density obtained in the laboratory. The variation in the thickness allowed is 6mm per 4.5m length of construction.

Finished surface. The asphalt concrete surface should be checked by a 3.0 m straight edge. The longitudinal undulations should not exceed 8.0 mm and the number of undulations higher than 6.0 mm should not exceed 10 in a length of 300m. The cross-traffic profile should not have undulations exceeding 4.0mm.

Advantages of Bituminous Road Construction Over Concrete Pavements. Bituminous road offers a smooth ride surface, gradual failure, quick repair, staged construction, Less life cost and temperature resistant.

Disadvantages of Bituminous Pavement. Bituminous pavements are less durable and low tensile strength compared to concrete pavement. Extreme weather and improper weather conditions tend to make bituminous pavement slick and soft. Bitumen with impurities can cause pollution to soil, hence groundwater by their melting. These may have hydrocarbons in small amounts. Clogging of pores and drainage path during construction and service life. More salting to prevent snow during the winter season. The cost of construction is high during extreme conditions of temperature.

Summary

Bitumen is one of the most consumed and versatile construction materials for road construction. Bitumen road is felt better riding comfort than a concrete road. Bitumen concrete is also carried out mix design then placed using paver machine for faster and quality construction of NH, SH and interior roads. Understanding the bitumen types, properties, tests involved and requirements for road construction are important for a highway engineer. Young engineers should further read about bitumen, test procedures and quality control aspects for the construction of flexible pavement roads and other use in building construcyion.

"They say life is a highway and we all travel our roads, some good, some bad,
yet each is a blessing of its own."

~ Jess Brynjulson.

## ANNEXURE–I

## PLINTH AREA RATES FOR THE YEAR 2021-2022 FOR THE PREPARATION OF ROUGH COST ESTIMATE

| Sl. No. | Type of Building | For works in Moffusil (other than Corporation Limits) | | | For works in Corporation Limits | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | In Trichy, Salem, Tirunelveli, Thoothukudi, Vellore, Tiruppur, Erode, Thanjavur, Dindigul, Nagercoil, Hosur and Avadi | | | In Chennai, Coimbatore and Madurai | | |
| | | Foundation | Super Structure | Roof Finishing | Foundation | Super Structure | Roof Finishing | Foundation | Super Structure | Roof Finishing |
| | | (Rate in Rupees per 1 sqm.) | | | | | | | | |
| 1. | **Residential** Load Bearing | 4140 | 9485 | 1605 | 4350 | 9970 | 1690 | 4460 | 10185 | 1735 |
| | Framed | 4910 | 13225 | 1645 | 5155 | 13885 | 1735 | 5295 | 14195 | 1765 |
| 2. | **Non-Residential** Load Bearing | 3185 | 8040 | 1605 | 3345 | 8435 | 1690 | 3435 | 8645 | 1735 |
| | Framed | 4910 | 9935 | 1645 | 5155 | 10430 | 1735 | 5295 | 10655 | 1765 |
| 3. | **Hospital** Load Bearing | 3185 | 9005 | 1605 | 3345 | 10045 | 1690 | 3435 | 9685 | 1735 |
| | Framed | 4910 | 13855 | 1645 | 5155 | 14560 | 1735 | 5295 | 14915 | 1765 |

**Note:-**

(1) For the calculation of Foundation Cost, Plinth area at Ground level of the building is to be taken.

(2) For the calculation of Super Structure cost, plinth area of respective floor of the building is to be taken.

(3) For the calculation of Roof finishing cost, Plinth area at Ground level of the building is to be taken.

(4) For School Buildings – the Super Structure cost will be 80% of Super Structure cost of Non-Residential Buildings.

(5) For stilt floor towards Car parking, Garages, Cycle Shed, Staircase Head Rooms etc., - the plinth area rate will be 65% of Super Structure cost of Non-residential building.

(6) For basement floor, an extra 25% over the super structure cost of respective type of building is to be added.

(7) In framed structure, where dummy columns are to be provided, a rate of Rs.500/$m^2$ of plinth area for Residential Building and a rate of Rs.394/$m^2$ for Hospital Buildings and Non-residential Buildings is to be allowed.

(8) For upper floors, an extra @ Rs.37/$m^2$ may be added towards lift charges for each floor.

(9) The additional rates allowed in the schedule of rates for works in Jails, Reserve forests, Hills and other Special tracts etc., shall be added to the above plinth area rates for works in respective areas.

(10) For works in the belt area of Chennai City, the plinth area rate applicable for Chennai City shall be adopted.

(11) For super structure in Earthquake prone areas, the rates in Annexure-V shall be adopted.

(12) All the above provisions shall be added only on the basic rates as approved in the table above.

(13) For works in coastal area, the following rates over the basic rate as approved in the table above, (for the total plinth area) shall be added for providing concrete of higher grade

a. Upto 10 km distance from Sea Water Front - Rs.267/$m^2$

b. Beyond 10 km and upto 24 km distance from Sea Water Front - Rs.134/$m^2$

**(14) PROVISIONS INCLUDED IN FOUNDATION RATE:**

(a) The rate given for foundation is applicable for Ground Floor + 2 Floors in the case of Load bearing structure.

(b) The rate given for foundation is applicable for Ground Floor + 3 Floors in the case of Framed structure.

(c) The rate given for foundation is to be calculated based on plinth area at Ground Floor of the building only.

(d) The depth of foundation assumed is 1.8m below GL with conventional stepped footing in the case of Load bearing structure.

(e) The depth of foundation assumed is 2.0m below GL with isolated footing in the case of Framed Structure.

(f) The foundation rate is inclusive of Earth Work, Sand filling, PCC 1:5:10 for Mat Concrete, Brick Work / Random Rubble Masonry in Cement Mortar, Re-filling the sides of foundation, Plinth beam including cost of centering, Cement Concrete, Steel, Damp Proof Course, Sand filling in basement and flooring concrete in Ground Floor in the case of Load bearing structure.

(g) The foundation rate is inclusive of Earth Work, Sand filling, PCC 1:5:10 for Mat Concrete, Cement Concrete, Centering, Steel for column footing, Pedestal, Column, Re-filling the sides of

foundation, Plinth beam, Brick work in Cement Mortar upto basement level, Damp Proof Course, Sand filling in basement and flooring concrete in Ground Floor in the case of framed structure.

(h) The foundation rates are applicable for building with basement at 0.9m height from ground level.

## (15) PROVISIONS INCLUDED IN SUPER STRUCTURE RATE:

(a) This rate is inclusive of Brick work, RCC, Steel, Centering, Plastering, joinery items with steel frames and M.D.F. shutter for doors, steel glazed windows and steel glazed ventilators, Grano flooring 25mm thick in the case of residential & non residential buildings, mosaic tile flooring in the case of Hospital building and Rain water down fall pipe of adequate dia.

(b) The height of each floor has been taken as 3.30m average.

(c) This rate is inclusive of provision for Anti-skid ceramic tile flooring and glazed tile dadooing in Toilets.

(d) This rate is inclusive of plastering with Cement Mortar 1:5, 12mm thick, white washing two coats over one coat of white washing for interior walls and colour washing two coats over one coat of white washing for exterior faces.

## (16) PROVISIONS INCLUDED IN ROOF FINISHING RATE:

(a) This rate is inclusive of weathering course, finishing with pressed tiles, providing parapet wall with Brick work in Cement Mortar, plastering, white washing for interior faces and colour washing for exterior walls.

## (17) EXTRA PROVISIONS TO BE ALLOWED OVER THE ABOVE RATE:

### (a) IN FOUNDATION:-

| Sl. No. | Type of foundation | Rate in Rupees per one sqm. | Area to which applicable |
|---|---|---|---|
| (i) | For stub column arrangements for Load bearing structure | 1250 | Plinth area at ground level |
| (ii) | For combined footing | 810 | Plinth area at ground level |
| (iii) | For strip raft | 3265 | Plinth area at ground level |
| (iv) | For raft (Floating Raft) | 4910 | Plinth area at ground level |
| (v) | For every additional 0.3m basement height | 480 | Plinth area at ground level |
| (vi) | For every additional 0.3m depth in foundation | 300 | Plinth area at ground level |

| Sl. No. | Type of foundation | Rate in Rupees per one sqm. | Area to which applicable |
|---|---|---|---|
| (vii) | For every additional floor over initial Ground + 3 Floors in case of Framed Structure | 665 | Respective floor area |
| (viii) | For Anti-Termite Treatment | 120 | Plinth area at ground level |
| **(ix)** | **Pile Foundation** | | |
| (a) | Upto 4 storeys for a depth of 15m | 9545 | Plinth area at ground level |
| (b) | More than 4 storeys but less than 8 floors | 12265 | Plinth area at ground level |
| (c) | More than 8 Floors | 16705 | Plinth area at ground level |
| (d) | **Add** extra for every one metre depth, if the depth of pile exceeds 15m | 535 | Plinth area at ground level |
| (e) | **Deduct** extra for every one metre depth, if the depth of pile is less than 15m | 255 | Plinth area at ground level |

**(b) IN SUPER STRUCTURE:-**

| Sl. No. | Description of work | Rate | |
|---|---|---|---|
| (i) | **For every additional 1m height** over the initial height of 3.30 m | Rs.615/$m^2$ | |
| (ii) | **Flooring:-** (Actual area of flooring has to be considered) | In Residential & Non-Residential Buildings | In Hospital Buildings |
| (a) | Grey Colour Mosaic Tiles | Rs.740/$m^2$ | NIL |
| (b) | Other Colour Mosaic Tiles | Rs.1000/$m^2$ | Rs.255/$m^2$ |
| (c) | Ceramic Tiles (not less than 305 x 305 x 6 mm size) | Rs.1070/$m^2$ | Rs.335/$m^2$ |
| (d) | Marble (Macrona) (not less than 600 x 600 x 18mm size) | Rs.2095/$m^2$ | Rs.1355/$m^2$ |
| (e) | Marble (White) (not less than 600 x 600 x 18mm size) | Rs.2335/$m^2$ | Rs.1600/$m^2$ |
| (f) | Marble (Adanga) (not less than 600 x 600 x 18mm size) | Rs.1745/$m^2$ | Rs.1010/$m^2$ |
| (g) | Rajasthan Kota Stone (Plain) | Rs.1245/$m^2$ | Rs.510/$m^2$ |
| (h) | Rajasthan Kota stone (Laid in combination with marble strips) | Rs.1420/$m^2$ | Rs.635/$m^2$ |

| | | | |
|---|---|---|---|
| (i) | Cuddapah Slab | Rs.930/$m^2$ | Not recommended |
| (j) | Stain Free Nano Polish Vitrified Tiles 600 x 600 x 8mm | Rs.1315/$m^2$ | Rs.565/$m^2$ |
| (k) | Double Charged Vitrified Tiles 600 x 600 x 8mm | Rs.1660/$m^2$ | Rs.910/$m^2$ |
| (l) | Double Charged Vitrified Tiles 800 x 800 x 10mm | Rs.1915/$m^2$ | Rs.1170/$m^2$ |
| (m) | Joint Free Rectified Glazed Ceramic Tiles 305 x 305 x 8mm | Rs.1270/$m^2$ | Rs.520/$m^2$ |
| (iii) | **Joinery:** (for any joinery like Aluminium (or) any other equivalent types of joineries if proposed) - Add extra | Rs.575/$m^2$ of carpet area | |
| (iv) | **Cement Painting if proposed:-** | | |
| (a) | For internal faces and external faces | Rs.555/$m^2$ based on plinth area | |
| (b) | For external faces only | Rs.265/$m^2$ based on plinth area | |

## ANNEXURE–III

## ELECTRICAL, WATER SUPPLY AND SANITARY ITEMS OF WORKS

| Sl. No. | Description of work | Rate in Rupees per one sqm. | Area to which applicable |
|---|---|---|---|
| 1 | **AC Provision for Office Buildings and in Hospitals (if proposed):-** | | |
| (a) | For non-ductable AC Units | 5470 | Floor area proposed |
| (b) | For ductable type AC Plants | 7290 | Floor area proposed |
| **Note:** | 1. The above rates are not inclusive of civil works such as construction of plant room, false ceiling, etc.<br>2. The above AC rates are inclusive of Supply, Installation, Testing, Commissioning and handing over of Air-Cooled Self Contained Ductable AC Units. | | |

| | | | |
|---|---|---|---|
| 2 | **Lift (if proposed):-** | | |
| **(a)** | **Passenger Lift** SS Body-304 Grade - Gearless) having speed 1m / second including power mains | With Machine Room (G+3) | Without Machine Room (G+3) |

| | | | |
|---|---|---|---|
| (i) | 8 Persons capacity (upto Ground + Three Floors) | Rs.21.97 lakhs | Rs.23.05 lakhs |
| (ii) | 10 Persons capacity (upto Ground + Three Floors) | Rs.22.99 lakhs | Rs.24.10 lakhs |
| (iii) | 13 Persons capacity (upto Ground + Three Floors) | Rs.25.58 lakhs | Rs.26.77 lakhs |
| (iv) | 20 Persons capacity (upto Ground + Three Floors) | Rs.31.81 lakhs | Rs.33.79 lakhs |
| **(b)** | **Bed-cum-Passenger Lift** (SS Body-304 Grade – Gearless) having speed 1m / second including power mains | With Machine Room (G+3) | Without Machine Room (G+3) |
| (i) | 15 Persons capacity (upto Ground + Three Floors) | Rs.26.90 lakhs | Rs.28.59 lakhs |
| (ii) | 20 Persons capacity (upto Ground + Three Floors) | Rs.32.14 lakhs | Rs.33.45 lakhs |
| (iii) | 26 Persons capacity (upto Ground + Three Floors) | Rs.33.45 lakhs | Rs.36.09 lakhs |
| **(c)** | **Dump Lift** (upto Ground + Three Floors) | Rs.8.94 lakhs | |

**Note:**

1. Provision for civil works such as construction of Lift Pit, Shaft, Machine Room, etc., are not included in the above rates.
2. **For Passenger Lift and Bed-cum-Passenger Lift** – For every additional floor over the Ground + Three Floors an extra at Rs.1,32,200/- shall be allowed for each floor.
3. **For Dump Lift** – For every additional floor over the Ground + Three Floors an extra at Rs.59,500/- shall be allowed for each floor.
4. **For Lift Pit** an extra at Rs.16,950/- per sq.m. of lift well sectional area shall be allowed.
5. **For Passenger Lift and Bed-cum-Passenger Lift** – Add extra Rs.66,130/- per Lift for Earthing, Shaft, Machine Power Mains as per CEIG Norms shall be allowed.
6. **Safety Certificate for Lift** has to be obtained by Supplier from CEIG.

| Sl. No. | Description of work | Rate | Allied works | Total |
|---|---|---|---|---|
| (3) | **High Tension Supply for 11 KVA Source of Supply** (including Erection, Testing, Commissioning and Allied Works) | | | |

| | | | | | |
|---|---|---|---|---|---|
| (i) | With Transformer upto 250 KVA **(Level-2)** | Rs.10.44 lakhs **(Level-2)** | HT/LT Cable | Rs.3.03 lakhs | **Rs.19.42 lakhs** |
| | | | MV Panel | Rs.2.64 lakhs | |
| | | | Safety Accessories | Rs.0.39 lakhs | |
| | | | APFC Panel | Rs.2.64 lakhs | |
| | | | **Sub-Total** | **Rs.8.98 lakhs** | |
| (ii) | With Transformer upto 500 KVA **(Level-2)** | Rs.14.35 lakhs **(Level-2)** | HT/LT Cable | Rs.3.64 lakhs | **Rs.26.31 lakhs** |
| | | | MV Panel | Rs.5.29 lakhs | |
| | | | Safety Accessories | Rs.0.39 lakhs | |
| | | | APFC Panel | Rs.2.64 lakhs | |
| | | | **Sub-Total** | **Rs.11.96 lakhs** | |

| **Sl. No.** | **Description of work** | **Rate** | **Allied works** | | **Total** |
|---|---|---|---|---|---|
| (3) | **High Tension Supply for 11 KVA Source of Supply** (including Erection, Testing, Commissioning and Allied Works) | | | | |
| (iii) | With Transformer upto 1000 KVA **(Level-2)** | Rs.23.44 lakhs **(Level-2)** | HT/LT Cable | Rs.3.97 lakhs | **Rs.37.05 lakhs** |
| | | | MV Panel | Rs.6.61 lakhs | |
| | | | Safety Accessories | Rs.0.39 lakhs | |
| | | | APFC Panel | Rs.2.64 lakhs | |
| | | | **Sub-Total** | **Rs.13.61 lakhs** | |

**Note:**

1. Provision for civil works such as, construction of Transformer Room, MV Panel Room, etc., are not included in the above rates.
2. Add extra for Service Connection Charges & Development Charges payable to TNEB and Approval Charges payable to CEIG.
3. If necessary, as per the approved design based on the site condition and CEIG Norms, add extra for the provision of Vacuum Circuit Breaker Panel and Ring Main Gear adopting Schedule of Rates, 2021-2022 shall be allowed.
4. Add extra of Rs.1,29,900/- shall be allowed for **22 KVA Source of Supply for Transformers**

| **4** | **Generator Set with AMF Panel:** | |
|---|---|---|
| (i) | 100 KVA capacity | Rs.11.06 lakhs |
| (ii) | 125 KVA capacity | Rs.12.32 lakhs |
| (iii) | 160 KVA capacity | Rs.16.57 lakhs |

| | | | | | |
|---|---|---|---|---|---|
| **6** | **Cold Storage facilities for Mortuary:** | | | | |
| (i) | 9 Bodies Capacity | | | Rs.17.03 lakhs | |
| (ii) | 12 Bodies Capacity | | | Rs.21.28 lakhs | |
| **Note:**<br>1. Cost of Mortuary Building not included in the above rates. | | | | | |
| 7 | **Public Address System:**<br>For Mini Conference Hall / Meeting Hall | | | | Rs.3.44 lakhs |
| 8 | **Intercom** with EPABX arrangements upto 300 lines | | | | Rs.20.67 lakhs |
| 9 | **Lightning Arrester** (For more than 5 storeys) | | | | |
| | **Description** | **Rate** | **Allied Works** | | **Total** |
| (i) | Lightning Arrester (Large) | Rs.1,16,900 | Mounting Structure | Rs.31,100 | |
| | | | Down Conductor (50 metres) | Rs.9,000 | |
| | | | Test Link | Rs.7,600 | |
| | | | Earth Electrode | Rs.14,100 | |
| | | | Surge Protection | Rs.29,700 | |
| | | | **Sub-Total** | **Rs.91,500** | **Rs.2,08,400** |
| (ii) | Lightning Arrester (Small) | Rs.1,03,900 | Mounting Structure | Rs.31,100 | |
| | | | Down Conductor (50 metres) | Rs.9,000 | |
| | | | Test Link | Rs.7,600 | |
| | | | Earth Electrode | Rs.14,100 | |
| | | | Surge Protection | Rs.29,700 | |
| | | | **Sub-Total** | **Rs.91,500** | **Rs.1,95,400** |
| | **Note:**<br>Add extra for additional down conductor at Rs.181/- per RM for the more than 5 storeyed buildings. | | | | |
| 10 | Civil Aviation Lights for buildings more than 8 storeys | | | | Rs.1.72 lakhs |

| 11 | Internal Water Supply, Sanitary Arrangements & Electrical Arrangements | | | |
|---|---|---|---|---|
| Sl. No. | Type of Buildings | Water Supply Arrangements | Sanitary Arrangements | Electrical Arrangements |
| | | Rate in rupees per one sqm. | | |
| (1) | Residential | 660 | 515 | 1055 |
| (2) | Non-Residential | 515 | 395 | 920 |
| (3) | Hospital | 660 | 515 | 1080 |

**Note:**

1. Add extra for provision of LED Lightings for Rs.153/- per sqm. of plinth area shall be allowed.
2. Add extra for provision of Computer Plugs for Rs.18.50 per sqm. of plinth area shall be allowed.
3. Add extra for provision of Power Plugs for Rs.25/- per sqm. of plinth area shall be allowed.

| 12 | External Water Supply, Sanitary Arrangements & Electrical Arrangements | | | | | | |
|---|---|---|---|---|---|---|---|
| Sl. No. | Type of Building | Water Supply Arrangements | | Sanitary Arrangements | | Electrical Arrangements | |
| | | Within existing well developed campus | New campus | Within existing well developed campus | New campus | Within existing well developed campus | New campus |
| | | Rate in rupees per one sqm. | | | | | |
| (1) | Residential | 400 | 795 | 150 | 245 | 340 | 705 |
| (2) | Non-Residential | 400 | 795 | 150 | 245 | 340 | 705 |
| (3) | Hospital | 400 | 795 | 150 | 245 | 340 | 705 |

**Note:**

1. The above rate is applicable only for ground and first floors on plinth area basis.
2. For every upper floor over the basic ground and first floor, 50% of respective floor area alone shall be taken into account for making provision towards external water supply and sanitary arrangements.
3. For every upper floor over the basic ground and first floor, 20% of respective floor area alone shall be taken into account, for making provision towards external electrification arrangements.

**for Engineer-in-Chief (Buildings) &**
**Chief Engineer (Buildings), PWD,**
**Chennai Region, Chennai-5**

Estd : 1941

# BUILDERS' ASSOCIATION OF INDIA

(All India Association of Engineering Construction Contractors)

**Southern Centre Estd : 1950**

## *MEMBERSHIP APPLICATION FORM*

To
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G-1/G-20, 7th Floor, Commerce Centre
J. Dadajee Road, Tardeo
MUMBAI – 400 034
Ph : 022-2352 0507 / 2351 4802
Website : www.baionline.in

Through
The Honorary Secretary,
BAI - Southern Centre
Plot No.A1, 1st Main Road, (Opp. to AIEMA)
Industrial Estate, Ambattur, Chennai - 600 058
Ph : 044-2625 2006
Web : www.baisouthern.com
E.mail : baisouthern1950@gmail.com /
baisouthern@yahoo.com

Dear Sir,

Please enroll my/our name (s) as PATRON / RENEWAL Member of Builders' Association of India. I/We am/are connected with the Building Profession / Trade / Construction industry as (please tick relevant box/s)

- ☐ Civil Construction Contractors
- ☐ Electrical
- ☐ Plumbing
- ☐ Fabrication
- ☐ Roads
- ☐ Water Proofing
- ☐ Interior decorator
- ☐ Repairs/Maintenance
- ☐ Real Estate Developer / Promoter
- ☐ Architect/Engineer
- ☐ Transporter
- ☐ Demolition
- ☐ Manufacturers /Suppliers
- ☐ Dealers/Hirers
- ☐ Engineering College/Polytechnics
- ☐ any other (specify)

**Registered With**

- ☐ Central PWD
- ☐ State PWD
- ☐ MES
- ☐ Railways
- ☐ Other State/Central Govt.Dept.(specify)

_____

_____

- ☐ any other (specify)

_____ _____ _____

_____ _____ _____

I /we specialise in _____

I/We have read the Rules and Regulations of your Association and agree to abide by the same. Please find herewith sum of

Rs._____/- (Rupees_____

_____) by Cash/Cheque/Demand Draft No _____ Dated

_____drawn on_____ in favour of "BUILDERS ASSOCIATION OF INDIA"

towards the membership subscription.

Yours faithfully,
(For & On Behalf of)

Date : ..... (To be signed by Proprietor / Partner / Director of Attorney / Authorised Signatory)

**(PTO)**

Fill below in Block letters:

I. Full Name and Address.....

.....

.....

.....

Tel : Office : ..... Res ..... Mobile: .....

E.mail: ..... GSTIN : .....

| 2.Give names in case of partnership firm/ Ltd Company /Institution and indicate against each whether Partner / Director / Executive attorney | Name of the Person who will attend and vote at the meeting with residence address and contact numbers |
|---|---|
| a)_____ | a)_____ |
| b)_____ | b)_____ |
| c)_____ | c)_____ |
| d)_____ | d)_____ |

Res / Address. & Tele. No. .....

.....

.....

PROPOSED BY .....

SECONDED BY .....

APPLICATION IN ORDER : FEES RECEIVED Rs. _____ Receipt No. _____

_____Date _____ Accepted by the Managing Committee at its meeting held on _____

at _____

SECRETARY'S NOTING SECRETARY

The Membership fees

The Patron Membership fee. Rs.50,000/- (i.e. Rs.29,700/- Membership fee inclusive of GST@ 18% and Centre's Corpus Fund donation Rs.20,300/-)

Renewal Membership fee. Rs.3627/- (inclusive of GST@ 18%)
Annual Membership fee. Rs.3745/- (inclusive of GST@ 18%)
Cheque may drawn in favour of BUILDERS ASSOCIATION OF INDIA.

**Please enclose Recent Passport Size Photographs - 2 Nos, Photo ID and Address Proof.**

Throuch RTGS / NEFT
Acct. Name : Builders Association of India
Bank Name : Indian Bank
Branch : Padi, Chennai
Account No. : 455121461
IFSC : IDIB000P001

# SOUTHERN CENTRE ACTIVITIES

09.10.2021 அன்று தென்னக மய்யத்தின் உபசரிப்பில் மாநில அளவிலான மூன்றவாது மேலாண்மை மற்றும் பொதுக்குழுக் கூட்டம் Hotel Feathers–ல் மிகவும் சிறப்பாக நடைபெற்றது. இக்கூட்டத்தில் பொதுக்குழு மற்றும் மேலாண்மைக்குழு உறுப்பினர்கள் கலந்து கொண்டு சிறப்பித்தனர்.

12.10.2021 அன்று தமிழக அரசின் ஏற்பாட்டில் நடைபெற்ற டெங்கு ஒழிப்பு விளிப்புணர்வு கூட்டத்தில் மாண்புமிகு மருத்துவம் மற்றும் மக்கள் நல்வாழ்வுத்துறை அமைச்சர் மா. சுப்பிரமணியன் அவர்கள், தென் சென்னை நாடாளுமன்ற உறுப்பினர் முனைவர் தமிழச்சி தங்கபாண்டியன் மற்றும் தியாகராயநகர் சட்டமன்ற உறுப்பினர் திரு. S. கருணாநிதி அவர்களும் கலந்து கொண்டனர். தென்னக மய்யத்தின் சார்பில் மய்யத்தலைவர் திரு. L. சாந்தகுமார் அவர்கள் கலந்து கொண்டார்.

21.10.2021 அன்று மாலை 3.00 மணி அளவில் நமது அறக்கட்டளை வளாகத்தில் உள்ள அரங்கில் கட்டுநர் தின விழாவை முன்னிட்டு "Role of Construction in Nation Building"என்ற தலைப்பின் கீழ் பொறியியல் கல்லுரி மாணவர்களுக்கான பேச்சுப்போட்டி நடைபெற்றது. இதில் Velammal Engg. College, TJS Engg. College, Sri. Venkateswara College of Engg, Sri Siva Subramaniya Nadar College of Engg. ஆகிய கல்லுரியிலிருந்து மாணவர்கள் பங்கு கொண்டனர். நடுவர்களாக முன்னாள் காப்பாளர் திரு. J.R. சேதுராமலிங்கம், தென்மண்டல செயலாளர் திரு. K. வெங்கடேசன், தென்னக மய்ய செயலாளர் திரு. A.N. பாலாஜி, ஆகியோர் பங்கேற்று பேச்சுப்போட்டியினை நடத்திக் கொடுத்தனர். மய்யத்தலைவர் திரு. L. சாந்தகுமார் அவர்களின் வரவேற்புரையுடன் பேச்சுப்போட்டி துவங்கப்பட்டது. 19 மாணவர்கள் கலந்து கொண்டனர். இதில் உடனடி முன்னாள் அகில இந்தியத்தலைவர் திரு. Mu. மோகன், விழுப்புரம் சாசனத்தலைவர் திரு. S. கணபதி, தென்னக மய்யப் பொருளாளர் திரு. N.G. லோகநாதன், இணைச் செயலாளர் திரு. R. நிம்ரோட், பொதுக்குழு உறுப்பினர் திரு. G. திவாகர் ஆகியோர் கலந்து கொண்டனர்.

22.10.2021 அன்று 30வது அகில இந்திய கட்டுநர் மாநாட்டின் கையேட்டினை (Brochure) L&T நிறுவனத்தின் முன்னாள் தலைமை நிர்வாகி திரு. K.V. ரங்கசாமி அவர்கள் வெளியிட்டார். மாலை 6.00 மணி அளவில் 7வது செயற்குழு கூட்டம் GRT Grand-ல் திரு. S.D. கண்ணன், திரு.T.V. சந்திரசேகர், திரு. R. ராஜேந்திரன், திரு. A. உதயசங்கர், திரு. G. யோகாநந்தன், திரு. R. ராமலிங்கம் ஆகியோரின் உபசரிப்பில் நடைபெற்றது.

கட்டுநர் தின விழா 29.10.2021 அன்று Park in Beach Resort–ல் வெகு விமரிசையாக கொண்டாடப்பட்டது. சுமார் 300 தொழிலாளர்களுக்கு சிறப்பு மருத்துவமுகாம் நடத்தப்பட்டது. மருத்துவ பரிசோதனை செய்து மருந்துகள் அளிக்கப்பட்டது. அகில இந்திய தலைவர் திரு. R.N. குப்தா அவர்கள் சிறப்பு விருந்தினராக கலந்து கொண்டு விழாவினை சிறப்பித்தார். பல்வேறு கலை நிகழ்ச்சிகளும், தொழிலாளர்களுக்கு சிறப்பு விருந்து, பரிசுப்பொருட்களும் வழங்கப்பட்டது. நமது நிரந்தர உறுப்பினரும், தாம்பரம் மய்யத்தின் சாசனத்தலைவரும், நாங்குநேரி சட்டமன்ற தொகுதி உறுப்பினருமான திரு. ரூபி R. மனோகரன் அவர்களின் சேவையை பாராட்டி அவருக்கு Citation மற்றும் டர்பன், மலர் மாலை அணிவித்து கவுரவிக்கப்பட்டார்.

28.10.2021 அன்று நமது இணைப்பு சங்கங்களின் (Affiliated) கூட்டம் நமது அலுவலகத்தில் நடைபெற்றது. அதில் கட்டுநர் தற்போது நிலவும் கட்டுமானப் பொருட்களின் திடீர் விலையேற்றம் பற்றி விவாதிக்கப்பட்டதாடு இதன் மேல் நடவடிக்கை தொடரவும் முடிவு செய்யப்பட்டது.

30.10.2021 அன்று நமது மய்ய அலுவலகத்தில் அகில இந்தியத்தலைவர் திரு. R. N. குப்தா அவர்களோடும், தலைமையக நிர்வாகிகளோடும் 30வது அகில இந்திய கட்டுநர் மாநாட்டுக்குழுத் தலைவர் திரு. R. இராதாகிருட்டிணன் மற்றும் நிர்வாகிகளும் கலந்து கொண்ட ஆலோசனைக் கூட்டம் நடைபெற்றது.

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