SP 70 (2001): Handbook on Construction Safety Practices [CED 29: Construction Management including safety in Construction]

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SP 70 : 2001

HANDBOOK
ON
CONSTRUCTION SAFETY PRACTICES

(First Reprint SEPTEMBER 2007)

ICS 91.200

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN. 9 BA6HADUR SHAH ZAFAR MARG
NEWDELHI 110002

March 2001

Price Gr 14

FOREWORD

Users of various civil engineering codes have been feeling the need for explanatory handbook and other compilations based on Indian Standards. The need has been further emphasized in view of the first publication of the National Building Code of India in 1970 (which has since been revised in 1983) and its implementation. The Expert Group set up in 1972 by the Department of Science and Technology, Government of India, carried out in depth studies in various areas of civil engineering and construction practices. During the preparation of the Fifth Five Year Plan, the Group was assigned the task of producing a Science and Technology Plan for Research, Development and Extension Work in the Sector of Housing and Construction Technology. One of the items of this plan was the formulation of design handbooks, explanatory handbooks and design aids based on the National Building Code and various Indian Standards and other activities in the promotion of the National Building Code. The Expert Group gave high priority to this item and on the recommendations of the Department of Science and Technology, the Planning Commission approved the following two projects which were assigned to the Bureau of Indian Standards (erstwhile Indian Standards Institution):

a) Development programme on code implementation for building and civil engineering construction, and

b) Typification of industrial structures.

A Special Committee for Implementation of Science and Technology Projects (SCIP) consisting experts connected with different aspects was set up in 1974 to advise the BIS Directorate General in identifying and for guiding the development of work. Under the first project, the Committee has identified several subjects for preparing explanatory handbooks/compilations covering appropriate Indian Standards/Codes/Specifications. The Handbooks published so far are the following:

*Handbooks published:

1. Design Aids for Reinforced Concrete to IS 456 : 1978 (SP 16 : 1980)
2. Handbook on Masonry Design and Construction (*first revision*) (SP 20 : 1991)
3. Summaries of Indian Standards for Building Materials SP 21 : 1983
4. Explanatory Handbook on Codes for Earthquake Engineering (IS 1893 : 1975 and IS 4326 : 1976) (SP 22 : 1982)
5. Handbook on Concrete Mixes (SP 23 : 1982)
6. Explanatory Handbook on Indian Standard Code of Practices for Plain and Reinforced Concrete (IS 456 : 1978) (SP 24 : 1983)
7. Handbook on Causes and Prevention of Cracks in Buildings (SP 25 : 1984)
8. Handbook on Functional Requirements of Industrial Buildings (Lighting and Ventilation) (SP 32 : 1986)
9. Handbook on Timber Engineering (SP 33 : 1986)
10. Handbook on Concrete Reinforcement and Detailing (SP 34 : 1987)
11. Handbook on Water Supply and Drainage with Special Emphasis on Plumbing (SP 35 : 1987)
12. Handbook of Typified Designs for Structures with Steel Roof Trusses (with and Without Cranes) (based on IS codes) (SP 38 : 1987)
13. Handbook on Structures with Steel Portal Frames (without Cranes) (SP 40 : 1987)
14. Handbook on Functional Requirements of Buildings (Other than Industrial Building) (SP 41 : 1987)
15. Handbook on Structures with Reinforced Concrete Portal Frames (without Cranes) (SP 43 : 1987)
16. Handbook on Structures with Steel Lattice Portal Frames (without Cranes) (SP 47 : 1988)
17. Handbook on Building Construction Practices (Other than Electrical Services) [SP 62 (S&T) : 1997]

This Handbook on construction safety practices which is one of the handbooks in the series has been prepared to meet the urgent needs of constructors, project managers and site engineers and deals with the safety in construction. Primarily, it is based on the Indian Standards on the subject. This Handbook which is a manual on

* Handbooks published are available for sale from BIS Headquarters and from all Regional and Branch Offices of BIS.

the safety practices in construction projects has universal applications to all construction activities, whether they result in buildings or dams or power stations.

The following points are to be kept in view while using the Handbook :

a) The Handbook does not form part of any Indian Standard on the subject and does not have the status of an Indian Standard. Wherever there is any dispute about the interpretation or opinion expressed in this Handbook, the provision of the code(s) only shall apply; the provisions of this Handbook should be considered as only supplementary and informative.

b) The list of Indian Standards published in the field of safety construction (*see* Annex E) and the bibliographical references used in preparation of the Handbook are given in Annex F.

This Handbook is based on the draft prepared by National Institute of Construction Management and Research, Mumbai. The draft handbook was circulated for review to Northern Railway, Delhi; Public Works Department, Punjab (B&R), Patiala; Bhabha Atomic Research Centre, Mumbai; Engineer-in-Chief's Branch, Army Headquarter, New Delhi; Public Works Department, Lucknow; Life Insurance Corporation of India, New Delhi; Housing & Urban Development Corporation Limited, New Delhi; Public Works Department, Maharashtra, Mumbai; Builder's Association of India, Chennai; Shri D.N. Chopra, New Delhi; Research Designs & Standards Organization, Lucknow; Chief Engineer, Army Headquarters, Delhi Zone, Delhi; Hindustan Pre-Fab Ltd, New Delhi; National Buildings Construction Corporation, New Delhi; Directorate General of Factory Advice Service and Labour Institute, Mumbai; Central Road Research Institute, New Delhi; Forest Research Institute, Dehradun; Gammon India Limited, Mumbai, Central Water Commission, New Delhi, Shri Tilak Raj Takulia, New Delhi; Plant Construction Organization, Durgapur; Acrow India Limited, Mumbai; Shri J. P. Mittal, Lucknow; Geological Survey of India (Western Region), Jaipur; Bhakra Beas Management Board, Chandigarh; Chief Technical Examiner (Vigilance), Bhopal; Central Board of Irrigation & Power, New Delhi; Central Electricity Authority, New Delhi; Continental Construction Pvt Ltd, New Delhi; Jaiprakash Associates Pvt Ltd, New Delhi; Karnataka Power Corporation Ltd, Bangalore; Kodampurai PSHE Project, Minparai Post (Tamil Nadu); Salal Hydroelectric Project, Jyotipuram; Tungabhadra Steel Projects Ltd, Tungabhadra; Central Vigilance Commission, New Delhi; Shri A. Nagabhushan Rao, Bangalore; Ministry of Transport (Roads Wing), New Delhi; Chief Engineer (Bridges), Central Railway, Mumbai; Bharat Heavy Electrical Ltd, Power Sector, Construction Management Safety Department, New Delhi; Som Dutt Builders Pvt Ltd, New Delhi; National Council for Cement & Building Materials, New Delhi; Structural Engineering Research Centre, Madras; Central Building Research Institute, Roorkee; Department of Science & Technology, New Delhi; Central Public Works Department, CDO, New Delhi; Metallurgical & Engineering Consultants (India) Ltd, Ranchi; Planning Commission, New Delhi; National Industrial Development Corporation Ltd, New Delhi.

INTRODUCTION

This Handbook on Construction Safety Practices has been prepared for site engineers, project managers and engineers-in-charge of buildings and civil works projects. It is based on the Indian Standards on the subject and is written in a readable style for easy reference by users.

Users should be conversant with technical as well as administrative/ legal aspects of safety, the former stem out of the standards and the latter from labour laws, contract document and judicial pronouncements. This Handbook deals with only the technical aspects of safety in construction.

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CONTENTS

		Page
1	EXCAVATION	1
1.1	Fencing	1
1.2	Shoring	1
1.3	Plant and Machinery	1
1.4	Access and Escape	2
1.5	Other Precautions	2
1.6	Common Hazards	2
1.7	Responsibility of Supervisor	2
2	DRILLING AND BLASTING	4
2.1	Transportation of Explosives	4
2.2	Handling Explosives	4
2.3	Indian Explosives Act, 1984	5
2.4	Guidelines for Storage of Explosives	5
2.5	Accidents while Using Explosives	5
2.6	Precautions during Usage of Explosives	5
2.7	Drilling for Blasting	6
2.8	Guidelines for Loading Blasting Agent	6
2.9	Shot Firing	6
2.10	Guidelines for Firing	6
2.11	Safety Fuse	6
2.12	Precautions for Firing	6
2.13	Disposal of Explosives	7
3	PILING AND DEEP FOUNDATIONS	7
3.1	General	7
3.2	Piling Rigs	7
3.3	Field Operations	7
3.4	General Precautions	8
4	TUNNELLING	8
4.1	Causes of Hazards	8
4.2	Drilling	8
4.3	Explosives and Blasting	9
4.4	Mucking Plant and Equipment	9
4.5	Supporting the Excavation	9
4.6	Tunnelling Machine	9
4.7	Tunnelling in Soft Ground	9
4.8	Working Through a Shaft	9
4.9	General Safety Measures	9
5	ROAD MAKING	10
5.1	Hot Mix Plant	10
5.2	Sprayers	10
5.3	Spreader and Paver	10
5.4	Heating Bitumen	11
5.5	Road Maintenance	11
5.6	Traffic Management During Road Construction/Repair	11
6	SITE TRANSPORT	11
6.1	Human Factor	11
6.2	Vehicles and Drivers	11
6.3	Loading	12
6.4	Hazard Control	12
6.5	Machine Faults	12
6.6	Other Dangers	13
7	FLOOR AND WALL OPENING	13
7.1	Floor Opening	13
7.2	Wall Opening	13
7.3	Cat-Walks	13
7.4	Stairways	14
8	DEMOLITION	14
8.1	General Precautions	14
8.2	Structure	14
8.3	Walls and Floors	14
8.4	Other Portions	15
8.5	Removal	15
8.6	Mechanical Demolition	16
8.7	Safety Checklist	16
9	STRUCTURAL STEEL ERECTION	17
9.1	Advance Planning	17
9.2	Erection Equipment	17
9.3	Structural Steel Works	18
9.4	Scaffolding	19
9.5	Form Work	20
9.6	Machinery	21
9.7	Surroundings	21
9.8	Other Precautions	21
9.9	Safe Practices	21
9.10	Guidelines of Safety Requirements to be followed at Sites of Construction Work	22
10	CONCRETE FRAMED STRUCTURE	22
10.1	Mixing of Materials	22
10.2	Placement of Concrete	22
10.3	Erection Equipment	23

		Page
10.4	Pre-stressed Concrete Members	23
10.5	Pre-fabricated Members	23
11	MATERIAL HANDLING	23
11.1	Acid	23
11.2	Acetylene	23
11.3	Bamboo	23
11.4	Brushes	23
11.5	Carbide	24
11.6	Casting	24
11.7	Cells (Battery)	24
11.8	Cement, Lime and Pozzolana	24
11.9	Cloth	24
11.10	Coal	24
11.11	Electrical Cables and Wires	24
11.12	Electrode	24
11.13	Firebrick	24
11.14	Glass Sheets and Plates	24
11.15	Leather Goods	24
11.16	Machined Parts	25
11.17	Oil	25
11.18	Oxygen	25
11.19	Paint, Varnish and Enamel	25
11.20	Paper	25
11.21	Petrol	25
11.22	Pipes	25
11.23	Rubber Goods	26
11.24	Steel Sections	26
11.25	Tools	26
11.26	Timber Components (Tool Handles)	26
11.27	Sand Gravel and Crushed Stones	26
12	COMPRESSED AIR	26
12.1	General	26
12.2	Equipment	26
12.3	Compression and Decompression	28
12.4	Working Chamber	28
12.5	Working in Compressed Air	28
12.6	Medical Lock	28
12.7	Fire Hazards	29
12.8	Detection of Gases	29
12.9	General Precautions	29
13	TOOLS	29
13.1	Electrical Tools	29
13.2	Electrical Safety	31
13.3	Pneumatic Tools	32
13.4	Abrasive Tools	32
13.5	Hand Tools	33
14	CONSTRUCTION MACHINERY	34
14.1	General Precautions	34
14.2	Earth Moving Machinery	34
14.3	Lifting and Hoisting Machinery	35
14.4	Transporting Machinery	36
14.5	Concrete Mixers and Batching Plants	36
14.6	Hydraulic Machines	36
15	COMMON HAZARDS	37
15.1	Air Borne Contaminants	37
15.2	Impregnation of Timber	37
15.3	Lead Poisoning	37
15.4	Toxic Fumes	37
15.5	Noise	38
15.6	Vibrations	38
15.7	Power Supply	38
15.8	Lighting	38
15.9	Maintenance	39
15.10	House-keeping	39
15.11	Material	39
15.12	Movement	39
15.13	Drowning	39
15.14	Openings	39
15.15	Weight	39
15.16	Occupational Health and Hygiene	40
15.17	Risks to Health at Work	40
ANNEX A –	Monthly Safety Report of Supervisor	41
ANNEX B –	Worksheet for Observation	43
ANNEX C –	Certificate of Test and Thorough Examination of Crane	43
ANNEX D –	Certificate of Test and Thorough Examination of Hoist	45
ANNEX E –	Indian Standards for Safety in Construction	47
ANNEX F –	Bibliography	49

HANDBOOK ON CONSTRUCTION SAFETY PRACTICES

1 EXCAVATION

1.1 Fencing

1.1.1 Where deep excavation is going on and there is likelihood of the public or cattle frequenting the area, suitable protective fencing should be erected and also sufficient number of notice boards and danger signals should be provided to prevent accidents by falling of persons in excavated trenches/pits. For excavated sites close to public roads/pathways, the area and the notice boards should have danger lights during darkness hours.

1.1.2 Barriers or coverings should be provided to excavations, shafts, pits and openings having a vertical fall distance of more than 2 m, except during the period necessary for the access of persons and movement of plant equipment and materials. A structure made of timber or other suitable material should be erected for excavating and earthwork operations in order to prevent any fall of rock or displacement of earth or other material adjacent to or forming the sides of the excavations.

1.2 Shoring

1.2.1 Timber has been used traditionally for shoring. Aluminium shores using hydraulic jacks to hold them in place are also used these days. They are economical and lightweight, can be installed and dismantled easily and have a longer life. They are also more safe than timber to use.

1.2.2 *Installation*

As far as possible, the installation of shores should be done from the surface; that is, vertical shores should be placed from surface and the first horizontal brace should be installed just below the surface from above. The operator should go down in the trench with the help of a ladder which is long enough to install the next lower brace or trench jack, etc. Thus, the trench is made safe for him to descend to install additional horizontal braces. The trench jack or horizontal braces should never be used as a ladder for getting in or out of a trench as they are not designed to take vertical load.

1.2.3 *Removal*

When the removal of shoring is planned, the possible collapse of trench sides should be anticipated. The newly installed utility line will then be safeguarded in the normal course by being covered with loose or compact fill before shores are removed. If the trench is likely to cave in on removal of the shores, it can be filled up to the bottom of the horizontal brace. It is a safe way for the worker to go down on the ladder and remove this brace, after which additional trench space can be filled up to the next horizontal brace or screw jack.

If the trench is to stay after the removal of shoring, the latter should not be removed till all work within the trench is completed and the newly installed utility line has been protected or covered.

A worker can then use a ladder to descend to the bottom of the horizontal trench jack and remove it. The remaining horizontal jacks should be removed as he ascends the ladder. The removal of shoring is a hazardous work. A worker should never be permitted to engage in this work single handed.

1.2.4 *Loose Site Material*

The most serious safety problem associated with deep highway cut is that of landslides. This may occur during the work or any time after completion. Damages include loss of life or body injury, more often after heavy rains when the soil loosens and becomes heavy with water.

All loose stones, projecting lumps or earth should be removed from the trenches. The excavated sides of a trench should be adequately guarded.

1.2.5 *Minimum Check and Clear Edge of Trench*

There is a tendency to dump the excavated material just on the edge of the trench where excavation is done manually. The material may slide back into the trench or apply additional load on shoring. A provision of clear berm of a width not less than one-third of the final depth of excavations is recommended. In areas where this width of the berm is not feasible, the reduced berm width of not less than 1 m should be provided. It is always better to provide substantial toe board to prevent 'roll back' into the trench.

1.3 Plant and Machinery

The excavation may be done manually or with the help of equipment depending on the volume of work and site conditions. The risk of accidents in mechanical excavations are more due to the speed of excavation and dumping of the material. The following safety measures are recommended.

1.3.1 The excavating equipment should be parked at a distance of not less than the depth of the trench, or at least 6 m away from excavated sides for trenches deeper than 6 m.

1.3.2 With the use of power shovels and draglines, the banks of trenches become unstable and thus dangerous for persons working nearby. These conditions should be watched and suitably remedied.

1.3.3 The vehicles should not be permitted to be driven too close to the pit. Care should be taken for locating roads leading to or from the pit. While loading manually, the vehicle should not be taken too near the wall of the pit. Use of spot logs will reduce risk of accidents where the vehicle is reversed for loading.

1.3.4 Workers should be provided with proper tools. Maximum hardness is the primary requirement for cutting edges and striking faces of tools. Overlooking the importance of providing the right tools for the job is perhaps the most serious risk to workers.

1.3.5 Workers using tools should guard against the danger arising out of the sudden movement of material which may throw them off balance. They should be adequately spaced to avoid being accidentally struck by tools of others working nearby.

1.4 Access and Escape

The workers should be able to escape fast in the event of any mishaps during excavation. It is recommended that one ladder should be provided for every length of 15 m or fraction thereof in the case of hazardous work, and 30 m of length or fraction thereof in the case of relatively less hazardous work.

Quite often the pathways become slippery due to accumulation of mud, sand or gravel. This should be avoided. Further, the pathways should be strong enough to withstand the intended use. Similarly, gangways should be of superior construction. The planks used should be strong, laid parallel to the length of the gangway and fastened together against displacement. They should be thick and have cleats for safe walking. Gangways should be kept clear of excavated material and other obstruction.

1.5 Other Precautions

Many accidents occur due to falls in unfenced trenches. Such accidents are more common during the rainy season. Fences, guards or barricades should be erected to prevent persons or livestock from falling into them. At night time, all public side walks and walkways should be adequately illuminated, and warning lights placed at proper sites to ensure safety of pedestrian and vehicular traffic. Sidewalks tend to become unstable during monsoons. They should be braced in the wet season. During excavation, the excavated sides should have the provision of steps or gradual slopes to ensure safety of men and machines in the area. It is possible that harmful gases and fumes are present in a trench. Gases, vapours and their metabolites absorbed by a human organ create morphological abnormalities and the individual develops symptoms of poisoning. To prevent such mishaps, dilution and exhaust ventilation system should be used to reduce the concentration of gaseous matter to the recommended hygiene standards.

Explosive mixed gases may also be present in the trenches. Air containing more than 1.5 percent of flammable gases by volume is dangerous. Gases and fumes should be rendered harmless or discharged at points that are sufficiently remote from the trenches.

Internal combustion engines emit hydro-carbon, carbon monoxide and nitrogen oxides, which are dangerous to health. Hence no internal combustion engine should be operated in a trench unless adequate precautions are taken.

Burrowing or mining or what is known as 'gophering' should not be allowed. In any trench where such methods are being followed, the cavity belt should be eliminated by cutting it back to the bare slope before removing any further material from the section of the trench.

Workers normally take their lunch under the shade near their work sites. If shade is not available, they tend to sit in the shade or undercut of the trench. This practice should be prohibited. While excavating near or below the building foundations, the latter should be supported by shoring, bracing or underpinning as long as the trench remains open.

1.6 Common Hazards

Vibrations caused by the operation of machinery at sites adjacent to the excavated pits may cause collapse of walls unless they are properly braced. Further, quick sand is a dangerous phenomenon which necessitates the use of continuous steadying.

Damp sand is non-stable and for proper support it may need bracing (*see* Table 1).

1.7 Responsibility of Supervisor

1.7.1 *Safety Check*

Experienced and qualified supervisors should be put in charge of the excavation work. They should understand their responsibilities and the details of all safety rules. A supervisor should have the authority to enforce all safety rules at site, prevent the use of defective safety appliances, rigging of tools and materials and to disallow any worker to handle jobs for which he is not qualified. The supervisor should brief workers about the working plan before the start of the work and explain

Table 1A Hard Soil General Instructions for Shoring and Timbering of Trenches

(*Clauses* 1.6 *and* 1.7.1)

Item No.	Depth of Trench	Sheathing		Wales		Struts			
		Section	Horizontal Spacing, *Max*	Section	Vertical Spacing, *Max*	Section		Spacing	
						Width of trench not more than 2 m	Width of trench between 2 m and 4 m	Vertical	Horizontal
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	m	cm	m	cm	m	cm	cm	m	m
1.	Over 2 but not over 3	5 × 20	2	15 × 15	1.5	10 × 10	10 × 15	1.5	3
2.	Over 3 but not over 5	5 × 20	1.5	15 × 15	1.5	10 × 15	15 × 15	1.5	3
3.	Over 5 but not over 6.5	5 × 20	1	20 × 20	1.5	15 × 15	15 × 15	1.5	3
4.	Over 6.5 but not over 8	5 × 20	Width of member	25 × 25	1.5	15 × 20	20 × 20	1.5	3
5.	Over 8 but not over 10	5 × 20	Width of member	20 × 30	1.5	20 × 20	20 × 25	1.5	3

Table 1B Soil which may Crack or Crumble

(*Clauses* 1.6 *and* 1.7.1)

Item No.	Depth of Trench	Sheathing		Wales		Struts			
		Section	Horizontal Spacing, *Max*	Section	Vertical Spacing, *Max*	Section		Spacing	
						Width of trench not more than 2 m	Width of trench between 2 m and 4 m	Vertical	Horizontal
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	m	cm	m	cm	m	cm	cm	m	m
1.	Over 1.5 but not over 2.5	5 × 20	1.5	10 × 15	1.5	10 × 10	—	1.5	3
2.	Over 2.5 but not over 3	5 × 20	1	15 × 15	1.5	10 × 10	15 × 15	1.5	3
3.	Over 3 but not over 5	5 × 20	0.5	15 × 20	1.5	10 × 15	15 × 15	1.5	3
4.	Over 5 but not over 6.5	5 × 15	Width of member	20 × 25	1.5	15 × 15	20 × 20	1.5	3
5.	Over 6.5 but not over 8	5 × 15	Width of member	25 × 25	1.5	15 × 20	20 × 20	1.5	3
6.	Over 8 but not over 10	8 × 20	Width of member	20 × 30	1.5	20 × 20	20 × 25	1.5	3

Table 1C Loose Sandy or Soft Solid or Soil which has been Previously Excavated

(*Clauses* 1.6 *and* 1.7.1)

Item No.	Depth of Trench	Sheathing		Wales		Struts			
		Section	Horizontal Spacing, *Max*	Section	Vertical Spacing, *Max*	Section		Spacing	
						Width of trench not more than 2 m	Width of trench between 2 m and 4 m	Vertical	Horizontal
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	m	cm	m	cm	m	cm	cm	m	m
1.	Over 1.5 but not over 2.5	5 × 20	0.4	10 × 15	1.5	10 × 10	10 × 15	1.5	3
2.	Over 2.5 but not over 3	5 × 15	Width of member	15 × 20	1	10 × 15	15 × 15	1	3
3.	Over 3 but not over 5	5 × 15	Width of member	20 × 20	1.5	15 × 15	15 × 15	1.5	3
4.	Over 5 but not over 6.5	5 × 15	Width of member	20 × 25	1.5	15 × 15	15 × 20	1.5	3
5.	Over 6.5 but not over 8	8 × 20	Width of member	20 × 25	1.5	15 × 20	20 × 20	1.5	3
6.	Over 8 but not over 10	8 × 20	Width of member	25 × 25	1.5	20 × 20	20 × 20	1.5	3

Table 1D Soil Under Hydrostatic Pressure
(*Clauses* 1.6 *and* 1.7.1)

Item No.	Depth of Trench	Sheathing		Wales		Struts			
		Section	Horizontal Spacing, *Max*	Section	Vertical Spacing, *Max*	Section		Spacing	
						Width of trench not more than 2 m	Width of trench between 2 m and 4 m	Vertical	Horizontal
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	m	cm	m	cm	m	cm	cm	m	m
1.	Over 1.5 but not over 2.5	5 × 15	Width of member	15 × 20	1.5	10 × 10	15 × 15	1.5	3
2.	Over 2.5 but not over 3	5 × 15	Width of member	15 × 25	1	10 × 15	15 × 15	1.5	3
3.	Over 3 but not over 5	8 × 20	Width of member	25 × 25	1.25	15 × 15	15 × 15	1.25	3
4.	Over 5 but not over 6.5	8 × 20	Width of member	25 × 30	1.25	20 × 20	20 × 20	1.25	3
5.	Over 6.5 but not over 8	10 × 20	Width of member	25 × 35	1	20 × 20	20 × 25	1	3
6.	Over 8 but not over 10	10 × 20	Width of member	35 × 35	1	20 × 25	25 × 25	1	3

potential hazards to them. The excavation work should be inspected by a qualified engineer once a week and after every heavy spell of rain or storm. Defects, damage or dangers found should be reported immediately to the site incharge and corrective action taken. He should pay a special attention to water pipelines, electric cables lying below the surface or during excavations of underground structures. The supervisors should ensure that all workers working under him are provided with safety appliances and protective equipment, and that they use it. The format of the Supervisor's Monthly Safety Report is given as Annex A. The worksheet for observation is attached as Annex B. General instructions for shoring and timbering of trenches is given in Table 1.

1.7.2 *Record Keeping*

Certificates and reports received by a contractor in respect of any test, inspection or examination of any equipment, excavation, shores, earthwork, etc, should be kept at the relevant construction site. These certificates and reports should be readily available for inspections by senior officers and other concerned authorities.

2 DRILLING AND BLASTING

Drilling and blasting is a major safety hazard on construction sites. Accidents generally happen due to the mishandling of explosives during transportation, carelessness in their storage, misfire, and not guarding the blasting area. The overconfidence on the part of workers/supervisors may also lead to accidents.

2.1 Transportation of Explosives

Three important items that need the consideration are:

a) Mode of transport,

b) Handling for transportation, and

c) Traffic on road and road conditions.

Explosives should always be transported in specially designed vehicles bearing special signs or inscription 'DANGER EXPLOSIVES'. Vehicles to be used for transporting explosives shall be in good working condition and shall have a light wooden or non-sparking metal like copper, brass, etc. Electrical wiring in vehicle shall be fully insulated so as to prevent danger of short circuiting and at least two fire extinguishers (of carbon tetrachloride type) shall be carried. No metal except approved metal truck bodies shall be allowed to come in contact with cases of explosives. Metal, flammable or corrosive substances shall not be transported with explosives. Smoking shall be prohibited in vehicles carrying explosives and no unauthorised persons shall travel in vehicle carrying explosives. Loading and unloading of explosives shall be done carefully by trained staff and supervised by qualified personnel. If possible, the traffic on the road while carrying explosives should be regulated specially in ghat and city areas.

The speed of explosive van and distance between the vehicle shall be regulated as per safety rules depending on road conditions. Badly maintained roads or speed breaker may jolt the explosives in the van if not properly placed or packed.

2.2 Handling Explosives

Dynamite may cause severe headaches, more so when it is unwrapped and handled with bare hand. Different brands and strengths of the dynamite vary in their headache producing property. Persons handling explosives should not smoke and carry no match boxes.

A complete list of safety precautions recommended by the manufacturers will be found in each box of dynamite and the same should be followed.

2.3 *Indian Explosives Act*, 1984

Storage of explosives is regulated by *Indian Explosives Act*, 1984 and provisions thereunder should be strictly observed. Accidental detonation of explosives during storage may be caused due to the following reasons:

a) Use of unsuitable rooms for storing explosives;
b) Unsystematic control of wiring systems, fire-alarm systems, store closing devices and stray currents; and
c) Careless handling, unwrapping and distribution of explosives.

2.4 Guidelines for Storage of Explosives

a) Explosives shall be stored only in a magazine or an isolated building which is clean, dry, well ventilated, seasonally cool, correctly located, substantially constructed, bullet proof and fire resistant and securely locked.
b) Actual requirements of explosives shall be drawn from the magazine and transported to the site.
c) In case of work at scattered places and for a small duration portable magazines shall be used and kept within a fence in a safe place and properly guarded.
d) These shall not be carried in the pockets of any clothing on any person.
e) Blasting caps, electric blasting caps or primers shall not be stored in the same box container or room with other explosives.
f) Explosives, fuse or fuse lighters shall not be stored in a damp or wet place or near oil, gasoline, cleaning solutions or solvents or near radiant or steam pipes or other sources of heat.
g) Smoking shall not be permitted within the fencing around the explosive magazine. No matches, open lights, or other fire or flame shall be allowed near the magazine.
h) Persons entering the magazine shall not have shoes with iron nails or other sparking metal.

2.5 Accidents while Using Explosives

Most of the accidents during the use of explosives are caused due to the following reasons:

a) Faulty loading of blast holes,
b) Failure to withdraw fast enough from the blast area,
c) Returning to blasting points too soon after firing, and
d) Presence of strangers near the blasting point, and
e) Premature detonation or misfire.

2.6 Precautions During Usage of Explosives

Following precautions should be taken during usage of explosives:

a) Any package containing explosives shall not be dragged, dropped or handled roughly. They shall be opened only at a safe distance and properly shielded from the packages of explosives in bulk storage.
b) No person shall strike, tamper with, or attempt to remove or investigate the contents of a blasting cap or attempt to pull out the crimped safety fuse out of a blasting cap.
c) Children, unauthorised or unwanted persons shall not be present where explosives are being handled.
d) No person shall handle, use or be near explosives during the approach or progress of any electrical storm. All persons shall retire to a place of safety.
e) Deteriorated or damaged explosives shall not be used and should be disposed off. Further no attempt shall be made to soften hard set explosives by heating over a fire or by rolling the explosive on the ground.

2.6.1 *Guidelines for Supervision*

The supervisors should take the following basic precautions at the blasting sites:

a) Smoking or carrying match boxes should be prohibited.
b) The package containing explosives should not be dropped or opened with metal tools.
c) Explosives should not be carried on the body of a person.
d) Persons not required during blasting should stay away.
e) Explosives should not be handled during the approach or progress of electrical storms.
f) Heating of explosives should never be done.
g) Explosives that have aged, deteriorated or are damaged should never be used.
h) Explosives should be placed in a hole that is not wet, is away from shocks/vibrations, and does not have rock splinters or sharp objects.
j) The fuse and the wire leads should be without top kinks.
k) Explosives should not be kept at places where they are exposed to flame, excessive heat or sparking.

2.7 Drilling for Blasting

A complete geologic and engineering evaluation is essential before drilling so as to avoid landslides after blasting. The face of the rock should be carefully examined to determine the possible presence of unfired explosives.

2.8 Guidelines for Loading Blasting Agent

a) All duct holes shall be sufficiently large to admit freely the insertion of explosion cartridges of explosives.
b) Tamping shall be done only with wooden rods without any metal parts.
c) Primer shall never be tampered.
d) If the loaded holes did not actuate no drilling within 17 m of the hole shall be done.
e) While loading after enlarging the hole or drilling, it must be ascertained that it is cool and does not contain any metal or burning or smouldering material. The temperature in excess of 65°C are dangerous.

2.9 Shot Firing

2.9.1 *Electrical Circuit*

Three main systems commonly used in blasting are—Condenser-discharge blasting machines, mechanically operated blasting machines and power line circuits. Of these three, the condenser-discharge blasting machine system is the most widely used. It is simple to operate and assures adequate firing current for almost any size of shot.

2.10 Guidelines for Firing

a) Before firing, sufficient warning shall be given to enable the people working in the blasting area to get out of the danger zone.
b) Any power circuit used for firing electric blasting caps shall not be grounded.
c) After firing the leading wires shall be immediately disconnected from the machine and short circuited.
d) Safety fuse only shall be used where sources of extra means of electricity is present.

2.11 Safety Fuse

In most construction jobs, the cap and fuse are normally used for secondary blasting. The length of a fuse should not be less than 120 cm, and the burning rate not more than 60 cm per minute.

The fuse wire should be lighted with a fuse lighter designed for the purpose. It should be lighted until sufficient stemming has been placed over the explosives. Only the prescribed explosives in the required quantity should be used in underground work.

2.11.1 As the fumes caused by the explosives may take a long time to emit out of the underground structure, a foul air duct of the specified size may be used to clean the air. It is more effective than a blow or pressure line. The velocity of the air at the delivery end should not be less than 0.2 m/s.

2.12 Precautions for Firing

2.12.1 *Precautions Before and After Firing*

a) Blasting shall be carried out during the fixed hours everyday or fixed days in a week. This information shall be amply publicised.
b) Road closing barriers should be provided at least 400 m away when firing is to take place.
c) The beginning of the firing should be followed by loud sirens and similarly the completion of the firing should be succeeded by loud sirens.
d) The shot firer shall not return to the blasting site after firing until at least 5 min have elapsed.
e) In case of electric shot firing the shot holes shall be examined after firing and incase of misfire no person shall be allowed to approach the blasting site for at least 5 min.
f) In case of shot firing with safety fuse, utmost care shall be taken to count the number of loud reports to ensure that all the shots have fired and in the event of blasting site for at least 30 min.
g) In case of misfiring no person other than those fully authorized shall approach the holes until the following operations have been performed in respect of each of the misfired holes.
    1) If a misfire is due to faulty cable or faulty electrical connection the defect shall be resumed and the shot fired.
    2) The stemming shall be floated out by use of water or air jet from hole until the hole has been opened to within 60 cm of the charge upon which water will be siphoned then fresh charge placed and duly detonated or a new hole shall be drilled 60 cm away from the old bore, parallel to it, about 60 cm less in depth and the new hole charged and duly fired.
    3) Careful search shall be made of unexploded material in the debris of the second charges.

2.12.2 The blasting operations shall be carried out scrupulously following the stipulations of the *Indian Explosives Act,* 1984 and Rules made thereunder and

by agencies in possession of licensing authority.

2.12.3 The preparation of charges, the charging of holes and firing shots shall be carried out by or in the presence of a responsible person with experience of handling explosives.

2.12.4 No more than 8 holes shall be loaded and fired at any one time.

2.12.5 It should be ensured that projection of fragment stones by explosives is minimum. For this purpose, it is recommended that before exploding any blasting charge, a strong wooden lattice of sufficient weight be placed immediately over the drift.

2.12.6 The blasting operation shall be carried out strictly in accordance with the stipulations under the license to carry out blasting operation.

2.13 Disposal of Explosives

a) Consult the manufacturers while disposing or destroying explosives and it should be done in strict accordance with the approved methods.
b) The materials used in the packing of explosives as empty cartridges, boxes, liners or other materials should not be left lying around.
c) The materials used in the packing of explosives as wood, paper, etc, should not be burnt in a stove, a fireplace or other conferred place, or to be used for any purpose.
d) The explosives should not be given on loan or parted or disposed off to anybody without the written permission of the competent authority.

In case of any theft, the matter should be reported to police and higher authority immediately.

3 PILING AND DEEP FOUNDATIONS

3.1 General

A basic step in safety in piling is that one must know the elements of machinery and equipment, how they can cause accidents and what steps should be taken by the operator to avoid accidents. Machines and equipment differ widely, depending upon the process and mode of piling, manufacturer's specialities, specification and allied factors. The safety requirements of each machine should be understood.

3.2 Piling Rigs

The legs of the tripod should be properly spiked in the ground. This will prevent accidents due slipping up of the tripod legs when rested on a paved ground or sleepers. The shear legs and bases become thin and fatigued with usage. They should be replaced frequently.

The failure of a pulley due to shearing of bolt or pin is quite common. Therefore, frequent check-ups of the pulley are essential. The wire rope forms the link between the main piling tools and the winch. Following regular checks are required in this respect.

a) Check for loose strands and wear, deformation, corrosion and breakage of wires.
b) Check whether the end of the rope has become loose or has slipped wire clips or wire sockets.
c) Check against slippage of rope from the sleeve during work.
d) Check if there is any occurrence of torsion while working and if so, rewind it normally at once.
e) Check if there are any adhesions like mud, earth, etc, on the rope. If so, clean with wire brush or compressed air.
f) Check if the grease applied on the rope is adequate.
g) Check for wear and cracks on the lining of the clutches and brake band; and the engine condition.

3.3 Field Operations

The common hazards in various field operations such as sheet piling, well foundation are mentioned below:

3.3.1 Sheet piling are normally used for construction of cassion or cofferdam to permit the de-watering of water for efficient under water working. They are handled manually, lifted by cranes and lowered by hammer or vibrostroker. The accidents due to drowning and injuries while handling are very common. These can be minimized by adopting the following precautions:

a) Hand ropes should be tied to control/prevent the movement of steel sheet sections that are transported.
b) Stirrups should be provided to workers engaged in interlocking the sheets.
c) Adequate pumping facilities shall be provided at cofferdam. Also adequate means of escape, such as ladders and boats shall be provided at cofferdams for protection of workers in case of flooding.
d) Adequate supplies of life saving equipment shall be provided for workers employed on cofferdams.

When sheet sections are being removed their movement shall be controlled by cables and other effective means.

3.3.2 *Well Foundation*

The progress and safety of well sinking depends on the knowledge of cutting edges provided by the

designer and the nature of sub-soil strata. The workers should also be got acquainted for taking precaution against danger such as appearance of heavy sand blow and consequent subsidence of peripheral areas. The common causes of accidents are given below:

a) *Centering the Pile* — The bailer is used for marking the pile centre. If a worker tries to loosen the sand at the location when the bailer is hanging over his head, he may get head injury.

b) *Driving the Casing* — The chances of a driving bar falling accidentally and injuring the worker are frequent.

c) *Driving Cap* - - The driving cap is suspended by a bar with the help of the clutch or a block. Instances of clutch and block giving way and the driving cap coming down are frequent.

d) *Lowering Reinforcement Cages* — Binding wire, wire nails, etc., are a very common source of injury to workers while preparing the pile cages or handling and lowering them.

e) *Jammed Casings* — Sometimes the casings get jammed. In the process of extracting them, the load on the tripod legs may increase and cause collapse of tripod. At times, this mishap may prove fatal. Likewise, if the jammed casings get released from the bore with a jerk, it may bring down the entire concrete, steel reinforcement, etc. The casing should be kept constantly moving so that it is free from concrete.

f) *Grounding the Bailers/Chisels* — The bailers and chisels tend to swing when they are grounded on completion of the operations. Workers should keep a safe distance.

g) *Completion of Pile Bore* — The accidents that occur after the bore is completed are due to the cut-off levels being lower than ground level. Also, the sand or bentonite used may conceal the steel bars of the pile which may cause injury to the legs.

Methane meters should be installed to detect methane and other hazardous gases. Blow is the most dangerous hazard in well sinking. The driver should be aware of this sudden phenomenon. Great care should be taken to prevent the driver from getting buried or injured. Open grab work winch engine should be running and be ready to avoid such mishaps. All driving equipment should be checked. Excavation work involving the use of jack hammers, pick axes, etc, should be carried out carefully and cautiously. The driver should not go under the cutting edge of the well curb.

3.4 General Precautions

a) All workers must wear tight fitting clothes or uniforms, helmets, hand gloves, protective footwear and eye protectors.

b) Electrical connections must be handled with a great deal of care. Direct tapping of power should be prohibited. Each unit should have its own switch board. All cables should be properly insulated and earthing done.

c) Engines must be stopped before fitting V-belts or flat belts on them.

d) Piling work causes vibrations that may damage the nearby structure, particularly the old ones. It is thus essential to keep watch on the old structure while piling work is being done.

The condition of structures around the piling area should be examined before starting work.

In the case of bored or cassion piles, there are more chances of the movement of sub-soil mass into the bore hole which may cause subsidence to some existing foundations in close proximity. This possibility is more likely in wet holes. Approved techniques for operation should be planned in such situations.

4 TUNNELLING

4.1 Causes of Hazards

The hazards involved in tunnelling and underground works are mainly due to the following operations :

a) Drilling

b) Explosives and blasting

c) Mucking plant and equipment

d) Supporting the excavation.

The surrounding environment like cramped working space, wet and slippery floor, inadequate lighting, obnoxious gases, etc, increase the chances of accidents.

4.2 Drilling

Drilling of holes is done by pneumatic rock drills mounted on the pusher air-legs or the booms of machines especially designed for underground works or from the drill platforms or jumbos.

A few basic precautions, if taken, can make the drilling operations fairly safe. The platforms or jumbos should be sturdy and well designed to give a rigid working place. Their surface should always be kept clean and non-slippery. Air hoses should not have been damaged.

The drilling should be resumed after ensuring that there are no misfired charges which the drill may strike. Finally, the charging of the drilled holes and the drilling should not be carried out simultaneously in the same area.

4.3 Explosives and Blasting

The provisions have been discussed in **2**.

4.4 Mucking Plant and Equipment

Before starting mucking operations, the reversible ventilation fans should be run till the fumes caused by explosives are removed. The supervisor concerned should be satisfied himself about the condition. The excavated profile should be carefully examined for loose rock which should be carefully scaled down before starting mucking.

If rail mounted tip wagons and locomotives are employed, the maintenance of the tracks, crossings and switches should be carried out regularly to avoid derailment. If diesel engine dumpers and loaders are used, they should be maintained properly so that the exhaust fumes are not excessive.

4.5 Supporting the Excavation

After the mucking operation is over, the profile of excavation should be examined by an experienced person who should decide whether the support in the form of rock bolts, steel ribs or shotcrete is required before any further operation is carried out.

In case of rock bolts, safety measures for drilling the holes should be observed before the bolts are fixed. The normal precautions for the erection of steel works including those of welding, should be taken in the case of steel ribs.

4.6 Tunnelling Machine

The use of tunnelling machines for boring reduce hazards as it eliminates drilling and blasting operations, reduces environmental pollution and poses less risk of collapsing of ground surfaces. For safety in the operation of tunnelling machines, a mole should be used where the tunnel length is more than 500 m. Their electrical connections and cables should be well insulated and the hydraulic hoses should be able to withstand high pressures. Care should be taken that the operator is well protected in the cabin and is otherwise comfortable.

4.7 Tunnelling in Soft Ground

In case of tunnelling in soft ground the bridging period is so short that steel supports cannot be erected. Therefore, the bridging time should be improved by shortcreting and the excavation supported to the extent feasible. Excavation of tunnels by drilling holes, and blasting with explosives is normally not done in soft ground. Other methods are followed. Precautions against hazards in the use of various other methods are given below :

a) *Forepoling* — If the forepoling is done by timber, the timber should be strong enough to take ground pressure, and it should be securely wedged. If the forepoling is done by steel rods, structurals etc, then the same precautions should be observed as required for machines.

b) *Shield Tunnelling* — The shield is operated by the hydraulic system. The safety measures for hydraulic machinery have been mentioned in **14.6**. The excavation behind the shield is lined with cast iron or concrete segments that are bolted together to form a rib. The handling and erecting of these heavy segments should be done with the help of hoists and platforms should not be slippery.

c) *Compressed Air Tunnelling* — In running grounds or where there is a substantial quantity of sub-soil water, tunnelling is carried out by compressed air locks. The relevant safety measures are given in **12**.

4.8 Working Through a Shaft

The use of shaft for construction purpose only or as a permanent structure in the hydro electric tunnels or transport tunnels is, at times, inevitable. Working through a shaft is an additional hazard in tunnelling and underground work. The following safety measures should be observed:

a) Hoists, sheaves, cables and head frames should be of adequate strength.

b) Shaft openings at the surface should be protected to prevent material and men falling into it.

c) The roof should be strong enough to protect men riding in it.

d) Hoists should be equipped with limit switches that give clear indication to the operator about the position of cage, that is, bottom or top of the shaft.

e) It is essential to provide automatic brakes that become functional in the case of electrical power failure.

f) The signal system should be foolproof and should be operated by trained personnel only.

For sinking the shaft, all precautions that are necessary for tunnelling should be observed.

4.9 General Safety Measures

Electrical supply and installations:

a) All equipment and cables should be capable of withstanding the damage likely to be caused by water, dust and humid atmosphere.

b) Suitable notices should be displayed where the

voltage is more than 220 V.

c) Only qualified electricians should be allowed to work on electrical installations.

d) Switches and electrical installations should be earthed and placed on high ground or platform.

e) The persons working in the tunnel should be provided with suitable protective wears, helmets, gumboots, etc.

f) The workers from the underground works should be withdrawn in case of prolonged ventilation failure or a heavy rush of ground water.

g) Good housekeeping is essential for safe and successful operations of tunnelling and underground works. All the debris, refuse, materials, tools and equipment, etc, not required for the operation of work should be removed from the tunnel.

h) Proper and adequate drainage inside the tunnel leads to safe working conditions. Sump pumps, switches and crossings of the fall tracks, transformers and installations of euipment should be well lighted.

j) All equipment and machines should be maintained in good working order.

k) The engineer/supervisor should inspect the machinery and equipment frequently and ensure that they are in good condition.

m) Gears and moving parts should be protected from dust and guarded to prevent accidental contact by operators.

n) Only experienced men should be allowed to operate the power plant.

5 ROAD MAKING

5.1 Hot Mix Plant

A Hot Mix Plant comprises of the following major components:

a) Feed hopper,

b) Dryer drum unit,

c) Hot elevator and gradation control unit,

d) Mixing unit, and

e) Bitumen unit.

For safe operations of the plant, the following procedure should be adopted :

a) Locate the plant in the direction of the wind. This will carry the dust away from the operating staff and stores.

b) Provide fire fighting equipment at the site. Store fuel and lubricants away from the plant.

c) Do not bring open fire near the fuel tank.

d) Helmets, gumboots, goggles and hand gloves should be provided to operators, mechanics and helpers working on the plant.

e) Staff should not wear loose clothing.

f) Check guards, canopies, etc, for their proper position and ensure that they are firmly fixed.

g) In the dryer drum, the flame burns at high speed and it has high temperature. Therefore, special precautions should be taken so that there is no leakage of fuel in the vicinity. Again, backfire is a very common incidence in the dryer drum. To prevent backfire, the fuel supply should be cut-off and heating tube thoroughly blown out by a fan.

h) The platform for operation should be strong and spacious and provided with side railings. A ladder should be provided for climbing up and down.

j) Since the temperature of the aggregate coming out from the dryer is quite high, the operator and helpers should take proper care to avoid direct contact with the aggregate or the dryer drum to avoid injuries due to burns.

k) The operator and helpers working at bitumen units should wear gumboots and hand gloves so as to avoid getting burns in the event of leakage of hot bitumen. Further, the operator should not lean over the mixer chamber to avoid being hit by jumping or flying particles of the aggregate. The mixer unit should be kept closed from the top.

5.2 Sprayers

The sprayer should be fitted with a fire resistant screen and an observation window. Its piping should be adequately insulated to prevent workers from getting burn injuries. Workers should stand in the opposite direction of the wind. This will avoid hot bitumen spray on their body.

5.3 Spreader and Paver

The general safety precautions and other safety measures prescribed for operating the equipment and starting the engine etc, hold good for the paver also. Additional safety precautions are given below:

a) Before switching on the auger/conveyor, ensure that the hopper is clear of unwanted material and there is sufficient mix material left in it.

b) Never lean on its side arms when the paver is working.

c) When paver is travelling, the screed should always be raised and secured.

d) Avoid over-vibration of screeds. When lighting screed burners, keep face and hands away from firebox. Never over-heat the screed.

5.4 Heating Bitumen

Tar requires heating before use. Vats, pots, drums and other containers are used for heating it. The container should be resistant to damage by heat and transportation. It should be leakproof and should have suitable outlets which can be controlled for taking out the hot material. The heating should be done in the presence of a person and the cover of the container kept closed. Observe temperature constantly. Avoid backfire. Use no open light to ascertain the level of binder in the boiler.

When bitumen is being heated in series of boilers the distance between two boilers should be about 1½ to 2 m to avoid spreading of fire to the adjoining boiler in case of any mishap. Leakage of bitumen from pipe joints/bitumen hot boilers should be checked as far as possible. In no case the leaked bitumen be allowed to remain around the work place at the end of the days work

While handling hot tar/ bitumen, workers should be careful to prevent accidental spillage. Buckets and cans for carrying hot material from boiler should be checked before use to ensure that they are intact and in safe condition.

5.5 Road Maintenance

Road maintenance possesses a greater variety of safety problems than do most other fields of heavy constructional engineering. Since hazards normally associated with such operations are multiplied several times over. The process of surfacing or resurfacing of a roadway involves the use of heavy mobile equipment and close proximity of moving streams of road traffic calls for a high degree of safety consciousness on the part of the work party as a whole.

The various hazards are mainly due to backing of truck to unload asphalt or crushed stones, hot asphalt (above 150°C) applied to road surface, fumes and dusts during asphalting, skin contact with concrete during placing, proximity of electric and water pipes, etc.

Responsibility of field engineer of road maintenance is many fold — it must ensure the safety of the general public, motorists, pedestrian, residents, workers and construction equipment. Priorities should be assigned to specific hazardous areas as determined by the locations, length of job, night time requirements, etc.

5.6 Traffic Management During Road Construction/Repair

There are broadly two types of diversions, namely new diversion road and portion of existing road duly upgraded serving as diversion.

In order to minimize traffic hazards and inconvenience to the users of the diversion roads and for safety of the personnel working at site the standard signs and caution boards in good and clear conditions should be displayed as per IRC codes.

6 SITE TRANSPORT

6.1 Human Factor

Almost 90 percent of the road traffic accidents are attributable to the human factor — the condition of vehicles and roads being the other. Studies conducted on the causes of accident have indicated that:

a) Young drivers have been increasingly involved in motor vehicle accidents.
b) Elderly drivers are more susceptible to accidents.
c) Age is an important factor in driving through different areas. Younger age drivers can drive more safely in urban/built up areas; elderly drivers are more safe on the highways.
d) The in-attention time gradually increases on a long drive on highways, thereby slowing the reaction time in an emergency. A car radio may help but will not improve the standard of driving.

Fatigue is more dangerous than most medical conditions.

6.2 Vehicles and Drivers

6.2.1 *Fitness of Vehicles*

All vehicles that are used on construction site must be in fit condition and should carry proper fitness certificate.

6.2.2 *Driving License*

A driver plying vehicle for site driving should be at least 18 years old and must hold a valid and current driving license issued by the prescribed licensing authority.

A driver driving vehicle of permissible weight exceeding 7.5 tonnes in the case of engineering plants and 3.5 tonnes in the case of dampers should be at least 21 years of age and must hold a valid and current driving license issued by the prescribed licensing authority.

6.2.3 *Driving Rules*

The person in charge of a project or a site, as the case may be, should impress on the drivers of vehicles under his charge to follow the driving rules. He should do spot checking occasionally to ensure that drivers follow the rules. Basically, he should ensure that the drivers:

a) follow the indications given by traffic signs,

b) comply with the traffic control signals on the roads,
c) stop vehicles at the unguarded railway level crossings, look right and left of the track and proceed further only when no train is coming from either direction, and
d) stop and proceed at unmanned or without signal road junctions.

6.3 Loading

6.3.1 Vehicle should be loaded as per the loading capacity specified by the manufacturer.

6.3.2 *Overloading*

Overloading causes more wear and tear of tyres, damages road surfaces and decreases efficiency of the moving components of a vehicle. Overloading may cause anyone or all of the following mishaps resulting in accidents:

a) Loss of control on steering,
b) Inadequacy of brake power,
c) Failure of components due to fatigue, and
d) Over-turning while negotiating sharp bends.

6.4 Hazard Control

6.4.1 *Marking Hazard Points*

When planning the site, the positioning of access points and the routing of site roads should be considered.

Site entrances should be so located as to cause the minimum possible inconvenience to the public or other road users. Suitable warning notices should be displayed at site entrances and public roads at sites. The provision of one-way systems and the avoidance of vehicle reversal is recommended on all sites, however small. Routes under or adjacent to overhead lines or near store areas should be marked by displaying appropriate danger signals.

Protective embankments should be provided at all excavation sites. They are particularly necessary where lorries or dumpers trip into excavations. Stops made of bulk timbers of about 300 mm square, securely anchored, are normally used for this purpose. Care must be taken to ensure that the timbers are moved and relocated as necessary when the work proceeds.

6.4.2 *Barriers for Overhead Lines*

The design and placement of overhead barriers as well as storing of metallic objects should be at a safe distance from the overhead lines. Where no work is done under the overhead lines nor any traffic or plant pass under them, the barriers should prevent inadvertent close approach. Where the work or traffic flow is under the overhead lines, defined access ways should be laid out. If work is done beneath the lines, expert advice for additional precautions should be obtained from the local electricity authorities, recorded and complied with.

6.4.3 *Road Conditions at Site*

The road maintenance at site is the responsibility of the project engineer. He must ensure that workers, residents, motorists, pedestrians and equipment move on the site without danger or damage. Specific hazardous areas should be identified after considering location, duration of site work, night time requirements, density of traffic, etc, and suitable warning devices installed. Proper shoring is essential where traffic or machines cause ground vibrations. If the travel path on the site cannot accommodate two-way traffic, flagmen or mechanical signals should be deployed for safe movements.

6.4.4 *Short-Cut Methods*

Many accidents at work places are caused by undue haste or short-cut methods in executing work, particularly when workers are on piece rate method of payment. These accidents can be minimized by strict safety supervision. Damage to structures can be avoided by erecting iron railings of suitable heights at corner where movement of vehicles is more frequent.

6.4.5 *Stacked Material*

Transport vehicles usually go to the stacked material site for loading either manually or by machines. In manual loading the vehicle is quite safe. In case of loading by a loader or clamshell, a strong canopy or cab should be provided for the safety of the driver. The engine of the vehicle should not run during the period of stacking.

6.4.6 *Services*

Electric supply lines, telephone lines and water supply lines normally go along the road side and cannot be protected at all times. Careless driving can disturb these essential services. The driver should be specifically instructed to avoid any damage to these essential services.

6.5 Machine Faults

6.5.1 *Starting and Setting*

Operatives should be instructed in the starting techniques for both petrol and diesel engines and the differences in the technique should be made clear to them.

6.5.1.1 *Petrol engines*

The starting handle should be fully engaged. It should

be gripped firmly by keeping thumb and forefinger together. The handle should then be pulled up a quarter of a turn and never pushed down.

6.5.1.2 *Diesel engines*

Set the fuel pump control in the overload position. Lift the decompression lever, which is usually situated on top of the rocker box. Ensure that the starting handle is fully engaged. Crank the engine. Start slowly and build up speed. Crank until the flywheel is turning reasonably fast and then drop the decompression lever. The engine should then start. Always stop the engine by using the fuel pump control and never by lifting the decompression lever.

6.5.2 *Checking*

The driver must carry out the specified "checks" of the machine before starting the day's work.

Manuals supplied along with the vehicle give instructions regarding these "checks". The usual check points are listed below:

a) Horn,
b) Emergency brakes,
c) Steering,
d) Wheel brakes,
e) Wiper,
f) Electrical lights,
g) Tyre pressure, and
h) Water in radiator.

6.5.3 *Maintenance*

The supervisor should ensure the systematic maintenance routine. Basic maintenance on a daily and weekly basis should be done by the drivers, who should report any defects immediately. However, a regular check should be done by experienced staff. Ensure that drivers are conversant with the maintenance routine. Never permit them to attempt repair work for which they have no expertise. Repairs carried out on site are potentially more hazardous and even experienced fitters sustain accidents at times.

6.6 Other Dangers

6.6.1 *Fuel Storage*

The quality of fuel items to be stored on site will obviously vary. Though from the safety angle it may be kept to a minimum, the storage of sizeable quantities may be unavoidable. The regulations permit up to 50 l of fuel in the general store provided the containers, cupboards or bins are made of fire resistant material. The bin or cupboard must have a retention sill to contain any spillage.

Quantities more than 50 l must be stored in a safe position either in the open air or in a store-room built of fire resistant materials. Again retention sills are necessary. Every storage area, bin or cupboard should be clearly marked "Highly flammable".

6.6.2 *Unattended Vehicles*

To the extent possible, the vehicles should not be left unattended during lunch and tea breaks.

Accidents due to unauthorised driving during lunch time are very common at sites. Before driving off, the driver should go around the vehicle to ensure that no man or cattle is resting under the vehicle or nearby under its shade. The engine should be shut off and cabin locked before leaving the vehicle.

6.6.3 *Hired Vehicles*

Contractors may hire vehicles at cheaper rates and they may not be road worthy. Therefore, only road worthy and mechanically fit vehicles should be hired. They are economical in the long run.

7 FLOOR AND WALL OPENING

7.1 Floor Opening

Any opening measuring more than 30 cm should be guarded by railing, fixed or removable, depending on the location. Stairway openings should be provided with fixed railing. However, for hatchway and chutes, the railings should be removable. The pits, manhole trap doors and floor openings should be covered. When the cover is not in place, the pit should be protected by removable railing. Every temporary floor opening should have railing.

7.2 Wall Opening

Every wall opening and chute with more than 120 cm drop should be provided with removable type hinged guards, preferably. A toe board placed below the guard will prevent the falling of materials.

Extension platform onto which materials may be hoisted should have side rails or guards along the entire length of the opening.

Every window wall opening at a stairway landing, floor, platform or balcony having a drop of more than 120 cm and where the bottom of the opening is less than 90 cm above the platform or landing should be provided with guards fitted with toe boards.

7.3 Cat-Walks

If a cat-walk is 120 cm or more above the floor level, it should be guarded by railings. If it is used for handling tools, machinery parts or materials, a toe board should be provided on each exposed side. If it is used for other purposes, like oiling of shaft and its

width is not less than 42 cm, then one railing may be provided.

Regardless of height, open-sided floors, walkways, platforms, or cat-walks above and adjacent to the dangerous equipment, pickling or galvanizing tanks, decreasing unit and similar other hazards, a railing fitted with toe board should be provided.

7.4 Stairways

Every flight of stairs having four or more risers should be equipped with stair railing or hand rails.

Additional hand rails of less than standard height should be mounted on stairway used by children. Staircases used by toddlers should have guards.

8 DEMOLITION

8.1 General Precautions

Demolition is more hazardous than construction or erection. It poses danger to men working on it, the public, equipment and the adjoining structures. Therefore, adequate attention should be paid to its planning and execution through various stages so as to minimize the risk of accidents and injuries to personnel engaged in it.

The nature of precautions that need to be taken depends on the type and height of the structure, reasons for its demolition, equipment to be used, duration, costs and the available technical know-how.

Following general precautions are necessary for all demolition work:

a) Danger signals should be conspicuously posted around the structure as well as at its doors and openings.
b) During night time, red lights should be placed on and around all barricades.
c) Watchman should be posted at entry points.
d) Protective equipment should be supplied to all workers and their use enforced.
e) Electrical wires, telephone lines and water pipes should be switched off when demolition work is in progress.
f) Protected walkways and passageways should be provided for the use of workers and others.

8.2 Structure

8.2.1 Removal of a member may weaken the side walls of an adjoining structure. To prevent any possible damage, the side walls should be supported until such time as permanent protection is provided. In case of anticipated danger to an adjoining structure, get the latter vacated.

If a structure under demolition has been partially wrecked by fire, explosion or other catastrophe, the walls and damaged roofs should be shored or braced suitably.

8.2.2 If the structure to be demolished is more than two storeyed or 7.5 m high, the adjacent road should be closed, or a side walk constructed on it (*see* Fig. 1). The side walk shed should be lighted to ensure safety at all times.

A toe board, at least 1 m in height above the roof of the shed, should be constructed on the outside edge and ends of the side walk. The roof of the side walk should be capable of sustaining a load of 730 kg/m.

Before demolishing a structure, attention should be paid to its structural design and condition of the concrete beams, columns and walls. Pneumatic drilled hand shearing machine or gas cutting set should be used to cut and demolish large quantity of concrete.

Hydraulic tools used in the demolition range from ordinary hydraulic breakers to highly specialized concrete crushing jaws and steel cutting shears.

Concrete up to 1 m thick may be cut with an abrasive water jet. The heart of the abrasive water jet cutting system has a small nozzle in which water is pressurized up to 4 200 kg/cm^2 and combined with solid abrasives to create a high velocity cutting jet. Cutting with a water jet minimizes dust and eliminates vibration and fire hazards.

Precast reinforced concrete units used in structures are normally held in position by the strength of joints made in site or on supporting walls etc. Before demolition of joint structures, their supporting mechanisms should be studied. For demolishing pre-stressed reinforced concrete, the advice of an expert should be taken.

8.3 Walls and Floors

In case walls are demolished manually, it should be done part by part. Lateral bracing should be provided if the height of a wall is more than 15 times its thickness or if it is in weak condition.

The wall should not be allowed to fall as a single mass on the floor of the building. The debris accumulated on the floor should be removed.

The structural or load supporting members on any floor should not be cut or removed until all the storeys above that floor have been demolished and removed.

Floors can be demolished by manual labour or with the help of equipment. About 300 mm wide slit should be cut in the first stage for the entire length of the slab along which it spans (*See* Fig. 2). The opening should

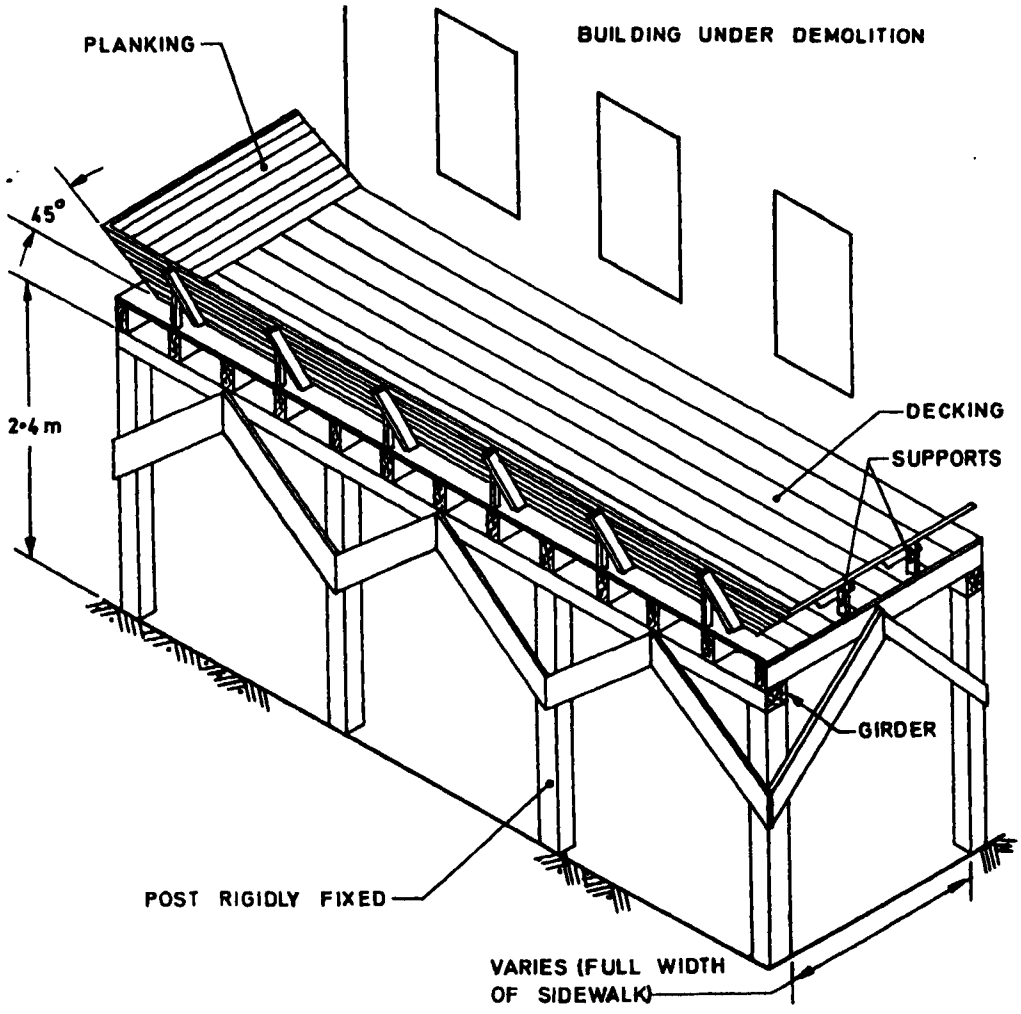


FIG. 1 TYPICAL SKETCH OF A SIDEWALK SHED

then be increased to the desired width in suitable stages. Sheet planks 250 mm wide and 50 mm thick and placed 0.4 m apart should be provided for workmen. When floors are removed no worker should be allowed to work in that area, or directly underneath; and such area should be barricaded. Demolition should start only after the floor and the surrounding area up to a distance of 6.0 m have been cleared of persons and debris.

If the surface of the concrete is smooth and regular, it may be cut with saws, abrasive water jet, thermic lance or pneumatic/hydraulic breaker. The choice of method is relative to the type of demolition required. Often shears and cutters are mounted on the boom of a hydraulic excavator for breaking reinforced concrete, etc. Derricks used for lowering the steel structure should rest on strong supports and should not be overloaded. A standard signal system should be used and workers instructed not to drop the load but lower it slowly (*see* Fig. 2).

8.4 Other Portions

The building under demolition may have jack arches, brick cantilevers, reinforced concrete, precast concrete, pre-stressed concrete, etc. The mode of demolition will vary according to the type of structure.

Heavy bulks of timber and steel beams should be supported before cutting at the extremities and then lowered to a safe working place.

In jack arches, the rods between the main supporting beams should not be cut until the arch or series of arches are removed.

For brick arches, expert advice should be obtained at all stages of demolition and it should be supervised by an experienced person.

8.5 Removal

One of the biggest problems in any demolition work is the disposal of the waste material. Normally, it is

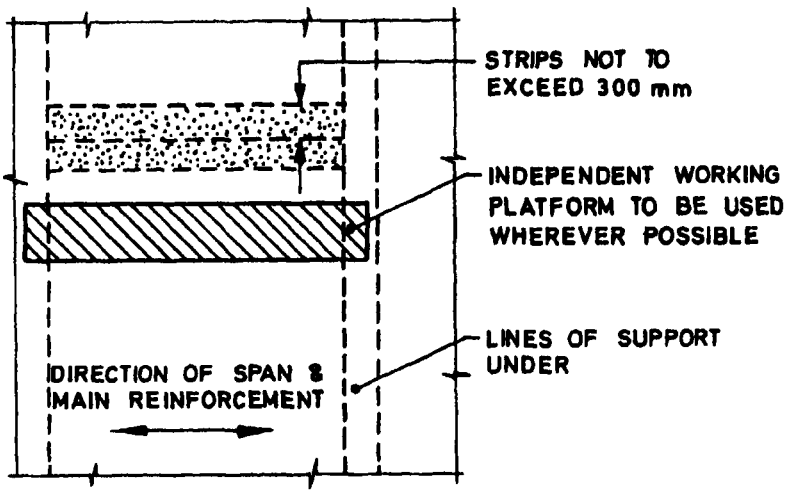


FIG. 2 DEMOLITION OF REINFORCED CONCRETE FLOORS

dumped near the demolished structure or on public roads. Materials should be thrown on ground only after taking adequate precautions. Wooden or metal chutes should be used for dropping the waste. Debris should also be dropped through the hole on floor without use of chute. Guard rails may be provided on surfaces on which men stand to dump materials.

8.6 Mechanical Demolition

The mechanical devices for demolition include weight balls, power shovels, concrete saw, etc.

The selection of the best method is a function partly of time, money and the surrounding environments.

The following precautions should be observed in mechanical demolition.

a) The area of demolitions should be barricaded for a minimum distance of 1½ times the height of the wall.
b) While the mechanical device is in operation, no worker should be allowed to enter the building under demolition.
c) The device should be so located as to avoid falling debris.
d) The mechanical device should not cause any damage to the adjacent structure, power lines, etc.

8.7 Safety Checklist

Irrespective of the method chosen for demolition or the size of the job, the following safety precautions should be observed :

Services — Gas, water, electricity and other services to the structure should be properly capped before starting demolition. Electricity or other lines needed to aid demolition should be of approved heavy duty construction and kept adequately protected along a known path.

Access — All movements of people within the structure should be on the designated routes, such as through prescribed doorways, stairways, or specially constructed walkways with fixed ladders. Removal of debris should also follow an agreed route. All other openings, horizontal and vertical, should be blocked off completely to avoid danger from falling material. Even openings needed for debris removal should be blocked when not in use.

Loading — Demolition may seriously change the loading designs. Any wall or floor required to carry excess weight of the stored material, or likely to be subjected to undue pressure from waste, must be adequately shored to withstand the extra loading. At no time should the debris be allowed to accumulate and become too weighty for the floor. High impact loads from falling debris is another source of unsafe loading. The lower walls of a building are particularly susceptible to the effects of destructive loading as they are not designed for it. Wind loadings may also be considered. Under no circumstances should the walls be left standing overnight if they are not plumb and strong enough to resist toppling by wind pressure. If wall stability is in doubt, demolition should continue down to the nearest structural cross member; alternatively temporary shoring should be erected. In general, no section of a wall more than one storey high should be left standing unsupported at any time unless it was specifically designed to stand higher.

Structural Members — When demolishing a structure from the top down, supports at the lower level should not be cut or removed until demolition at the upper level is complete. Care should be exercised in removing load-bearing beams and columns which tie

into party walls. Beams and columns that are cut should be well secured with rope or chains. If the volume of debris is expected to be large, the ground floor space to dump it should be increased.

Worker Protection — Workers engaged in the demolition jobs should always stand on firm base. Free ends of cut members may be needed as work platforms and must therefore be shored.

Other Hazards — All glass and combustible material should be removed from the structure before demolition begins. Removal of asbestos and poly-chlorinated bi-phenyls (PCBs) must be done in accordance with regulations set by the Occupational Safety and Health as well as the Environmental Protection Rules. These materials can be extremely dangerous to workers.

9 STRUCTURAL STEEL ERECTION

9.1 Advance Planning

The erection of structural steel can be divided into two separate operations that is, advance planning and field operations. The success of the field operations depends, in a large measure on the care and thoroughness of the advance planning. Drawings and layouts of large bridges and complicated buildings guide the field personnel through each step. The sequence of transporting and erecting must follow specific patterns. The size and weight of individual pieces must be within fabricating capacity, transportation limitations and erecting equipment capacity.

9.2 Erection Equipment

The hoisting equipment used to erect steel structure includes derricks, cranes, and variations of these units.

9.2.1 *Cranes and Derricks*

a) No crane should be used unless a competent person has inspected and tested it and furnished a certificate specifying the maximum safe working load.

b) Access to and egress from the operator's stand should be safe from any position of the crane.

c) Cranes should not be used to pull out fixed objects with a slanting pull, drag objects or move vehicles.

d) Before being put into use for the first time, jib cranes with variable radius should undergo tests of stability and of all movements such as travel, swinging, raising and lowering the load, braking the crane and braking the load.

e) Jib cranes should not be operated in dangerous proximity to electric power lines.

f) Derricks should be erected on a firm base and adequately secured against displacement.

g) Suitable devices should be used to prevent masts from lifting out of their seatings.

h) The mast of guy derricks should be supported by adequate guys spaced equally.

j) When a derrick is not in use, the boom should be lowered to prevent it from swinging.

k) No crane should be used in weather likely to endanger its stability.

9.2.2 *Hoists*

a) Hoists must be enclosed at ground level by substantial enclosures and gates at least 2 m high and the enclosures should be extended to accommodate the engine or motor.

b) Gates of the same height of 2 m must be provided at all the landing stages.

c) The complete hoist way throughout its height shall preferably be enclosed with wire mesh in order to contain the accidentally dislodged material from the hoist platform.

d) There must be only one operating position for the hoist and driver must be trained in the job and be able to see the platform of the hoist throughout its travel.

e) All material carried on the platform must be so placed as not to be dislodged and any moveable equipment, wheel-barrows etc, must be scotched.

f) The safe working load must be plainly marked on the hoist and never exceeded.

g) Every hoist must be fitted with an automatic device which will support the platform in the event of any failure of the ropes or gear.

h) Every hoist must be inspected once in the week.

j) The following message should be prominently displayed for benefit of the users. In case of failure of hoist during the operation, do not get panicky and call for help.

k) Check wire ropes of hoist frequently (*see* Table 2).

9.2.3 *Wire Rope*

Wire rope on hoists in continuous service should be visually inspected daily. Hoists operating round the clock should be visually inspected at the start of each shift. The visual inspection may indicate the need for a more thorough inspection. Strength of a used wire rope must be evaluated carefully.

Signs of wire rope deterioration and guidelines for wire rope replacement are shown in Table 2.

The term "one rope lay" refers to the axial wire rope length for one wire rope strand to completely wrap around the wire rope assembly. When a wire rope inspection is

Table 2 Deterioration Causes for Wire Rope Replacement for Overhead Lifting for Cranes, Hoists and Monorails

(Clauses 9.2.2 and 9.2.3)

Signs of Deterioration	Cause of Replacement	
	For Rope Diameters	Reduction More than
Reduction of rope diameter because of.		
a) Loss of core support	Up to 8 0 mm	0 4 mm
b) Corrosion	9 5 mm to 13 0 mm	0 8 mm
c) Worn outside wires	14 5 mm to 19 0 mm	1 2 mm
Broken outside wires	a) Twelve randomly distributed broken wires in one rope lay b) Four broken wires in one strand in one rope lay	
Wear of individual wires	Wear of one-third of the original diameter of outside individual wires	
Corroded, broken, cracked, bent or worn at end	Any of these conditions indicates need for replacement	
Severe kinking, crushing, cutting or unstranding	When such faults etc, result in distortion of rope structure	

NOTE — Evidence of any heat damage from any cause or weld splatter on rope are sufficient reasons for questioning safety and considering replacement

made, particular attention should be given to sections of wire ropes subjected to reverse bends or operations over drums and all sheaves including equalizers.

Replacement of wire rope should be of the same size, grade and construction as the original furnished by the hoist manufacturer, unless otherwise recommended. The replacement wire ropes should be stocked for hoists which are in continuous service. Care must be exercised in storing the replaced wire ropes against damaged and deteriorated, kinked and twisted ones.

9.3 Structural Steel Works

9.3.1 *Columns*

The strength and the main support to a building are provided by its columns. The columns, in turn, are anchored firmly to the foundations by means of holding bolts. Sometimes, the columns may have loose holding bolts that are grouted in concrete after the structure is levelled, aligned and plumbed. They are held in position prior to grouting by temporary guys. Often, some of the guys are required to be loosened or removed temporarily to facilitate erection of other components of steelwork. Here, even a little carelessness can bring the entire structure down resulting in serious or fatal accidents. The basic safety practice in this case is that the erector should get the first four columns of a bay, facing diagonally opposite to one another grouted soon after the bracing of the steelwork and its aligning and plumbing the portion of structure. It is advisable to use anchored heavy duty bolts with open pockets. It will facilitate easy erection and alignment.

9.3.2 *Levelling, Aligning and Plumbing of Columns*

For levelling, aligning and plumbing of columns, screed bars or level pads are generally provided. In some cases, they are not provided for columns of light and medium structures. The erection of steel work may proceed row after row without initially paying sufficient attention to levelling and plumbing of columns. It becomes difficult to bring the structure in plumb subsequently in the absence of level pads. Thus the structure remains out of plumb and it may collapse if subjected to winds of high velocity. Such mishaps can be minimized by getting the level pads fixed on footings of all main columns.

9.3.3 *Slinging of Heavy Components*

Sometimes the design of the structure may not facilitate the slinging of heavy components from structural members for hoisting. Such a design is not safe. Further, the de-slinging of the tall erected columns, especially the plain plated, may pose a problem. In such cases, the rigger climbs up the structure with the help of a rope or a rope ladder fixed to the column before lifting the same. This design is not safe. It is necessary to design a proper access to the weldable bent rungs and other points.

9.3.4 *Fastening*

The upper parts of tall structures are subject to higher wind pressure due to higher wind velocity at higher altitude. It is advisable to stabilize the erected anchored columns by fastening temporary wire guys till four-column-square is completely braced, levelled and plumbed.

9.3.5 *Lifting of Columns*

Usually, the foundation pits are back filled with loose earth but the area is seldom rammed.

Thus, while lifting the heavy columns by a crane, the earth under the forefront of the crawler gets depressed, the front portion of the crawler sinks and the load gets thrown out of radius. Consequently, the crane looses its stability and topples over, causing fatalities. Therefore, the filled in pits must be either manually rammed or rolled over by a heavy roller, and sleepers should be laid over the area. This arrangement will increase the stability of the crane.

9.3.6 *Safety in Erection*

Safety practices for erection will vary as per the job. For buildings, riveting or welding should be done to maintain stability of the structural frame at all times during the construction. Safety nets shall be provided within two stories or 10 m below the height of work which is being performed. Safety belt with lanyards attached to catenary line or other substantial anchorage should be used by workers on work which exposes to working at heights of 10 m or more. Personal protection equipment of the specified standard should be used by all workers.

9.4 Scaffolding

Scaffolds are essential practically at all stages of construction. All those work that cannot be conveniently carried out from ground floor or with the use of the ladder needs scaffolds. Accidents happen due to either collapse of the scaffold or falls of workers and materials from the top of the scaffold. Great care is, therefore, necessary in erection, use and dismantling of scaffolds.

9.4.1 *Design Safety*

The design of scaffolding needs the same skill and attention as the design of any permanent structure. The designer should ensure that drawings and instructions show sufficient details and that they are easily understood by erectors. Lateral stability is equally important. Most of the centering are designed for vertical loads. The lateral forces as a result of the dynamic effect are usually neglected during the design. Horizontal bracings are essential at various levels to ensure that support struts and scaffold tubes do not buckle under vertical load.

The Designer/Erector should ascertain from the manufacturer the safe load it can carry and the scaffolding should be inspected before use.

9.4.2 *Materials*

A scaffold framework may be constructed of timber or metal or a combination of the two. Metal scaffolds are commonly constructed throughout with 50 mm diameter nominal seamless mild steel tubing. Working platforms are nearly always constructed with timber planks of about 40 mm thick × 3.4 m long × 230 mm wide. All the components and materials should comply with relevant statutory requirements and standards.

9.4.3 *Hazards*

Accidents due to scaffold collapse are common. Apart from collapses, the principal hazards are the following:

a) Unsecured ladders slip,
b) Use of unsuitable or faulty materials,
c) Inadequately supported scaffold board,
d) Inadequate or irregular platform width,
e) Omission of guards rails or toe boards,
f) Failure to secure scaffolds to the building or to trace it adequately, and
g) Overloading of platform and scaffolds.

9.4.4 *Safety Measures*

a) Scaffolds must always be erected, maintained and dismantled by competent and trained workmen.
b) Scaffolds must be properly braced and when necessary tied into building or the structure. Platforms must be properly supported and span of planks should not be too great. They should not be overloaded.
c) Guard rails and toe boards must always be fitted and be maintained in position.
d) Loose packaging such as bricks should never be used below standards. Standards should be vertical and if of metal, should be mounted on steel base plates.
e) Ledgers should be horizontal and always be connected to the standards by load bearing lashings, if of timber or by right angle load bearing couplers, if of metal.
f) Transoms and putlog should be horizontal and at right angle to the ledgers, to which they should be secured by right angle couplers or putlog couplers.
g) Platforms should be close boarded; overlapping of boards and excessive overhangs should be avoided.
h) Diagonal bracing parallel to the face of the building and full height of the scaffold should be provided at 30 m intervals (*see* Fig. 3).

9.4.5 *Inspections*

Scaffolding should be inspected at least every 7 days or after any damage or occurrence of weather conditions (storms or frosts) which may have affected its safety or security. The main points to be checked are:

a) The alignment and support of the standards,

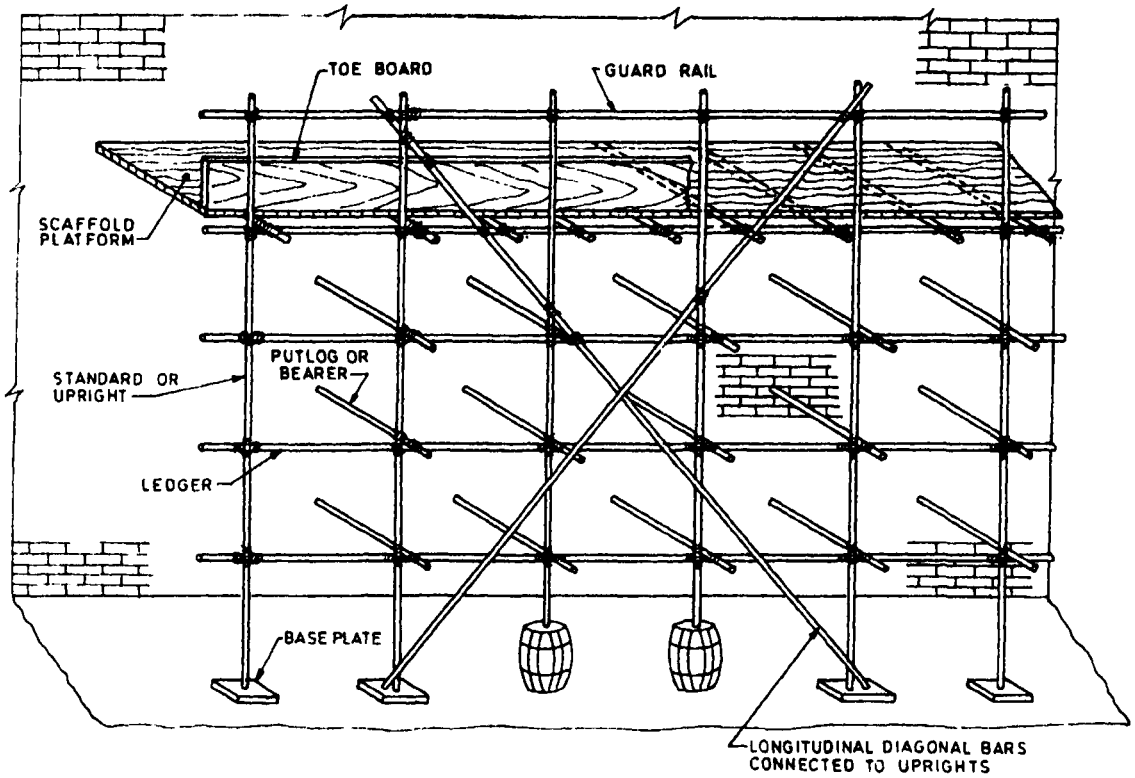


FIG. 3 TYPICAL SKETCH OF SCAFFOLD/BRACING

b) The straightness of the ledgers,
c) The adequacy of bracing,
d) The ties of the building,
e) The tightness of lashings or couplers,
f) The soundness, support and security of planks and platform,
g) The guard rails and toe boards, and
h) The conditions and security of the ladders.

9.5 Form Work

The form works are designed after taking into consideration the span, dead load and working load. Their main use is to support construction material like stone and bricks in arches or concrete and they must retain the final size and shape without causing excessive deflection or loss of moisture.

The material used for form work may be timber, metal tubes and mild steel sheets. Sliding form works are now common. Slip forms are normally used for vertical structures such as silos, storage bins, chimneys, bridge piers etc. They have advantage of giving good finish, reduced cost etc.

Conventional form work is normally supported by centering made out of wood or mild steel tubular steel. The form work once carefully designed, made and adequately braced will need not much attention or safety precaution. It is the centering, may be of wood or steel, that needs attention to prevent accidents.

9.5.1 *Erection*

Suggestions for erection of centering are given below:

a) Vertical supports shall be adequately braced.
b) Tubular steel centering should be used in accordance with the manufacturer's instructions.
c) Tubular steel should be inspected for rusting, dents, damaged welds, etc, before it is erected.
d) The centering should be designed by a competent engineer.
e) Sills under the support should be set on firm soil or other suitable material in a pattern which assure adequate stability for all props.

9.5.2 *Inspection Before Work*

a) The footings or sills under every post of centering should be sound.
b) All lower adjustment screws or wedges should be snug against the legs of panels.
c) All upper adjustment screws or heads or a jack should be in full contact with the form work.
d) Panels should be plumb in both the directions.
e) All cross brace should be placed and locking

devices in closed and secure position.

f) In case of *chajjas* and balconies, the prop should be adequate to transfer the load to supporting point.

g) The props should be of full length and not made of two pieces and joined by nailing with joint pieces.

h) The wedges, if used at the bottom of the prop, should be tight.

j) Load test should be carried out as prescribed.

9.5.3 *Inspection During Work*

During pouring of concrete, the centering should be constantly inspected and strengthened, wedges below the vertical supports tightened and adjustments screws properly adjusted.

9.5.4 *Removal of Formwork and Scaffolding*

a) The formwork should not be removed before concrete has developed sufficient strength to support itself as well as the loads that are on it. Guidelines given in relevant Indian Standards should be followed regarding the period of removal of the formwork .

b) Only workmen actually engaged in removing the formwork should be allowed in the area during the operation.

c) Workers engaged on this work should wear helmets, gloves, heavy soled shoes and safety belts.

d) While carrying any tying wires in tension, care should be taken to prevent backlash which might hit the workman.

e) The formwork should be dismantled as per the instruction of site engineer.

9.6 Machinery

Construction of tall buildings requires the use of cranes, hoists, elevators, etc. The location of these machines should be carefully selected. If located inside the structure, the floor openings and other spaces should be provided with guard rails.

9.6.1 *Cranes*

Travelling cranes or fixed tower cranes should be installed on good solid foundations and they should be braced properly beyond permissible free standing height.

9.6.2 *Hoists*

Hoists used for transporting workers should be provided with safety catches. This is a device whereby if the wire-rope snaps, the cage is held on to the vertical guides by the catch.

9.6.3 *Elevators*

Elevators should not be used for movement of workers till the installations are certified safe. Slings should be inspected by a qualified craftsman. Ropes and chains employed on work sites should be inspected regularly.

Riding on loaded hooks, brackets etc, by workers should be strictly prohibited.

9.7 Surroundings

a) The construction of staircases should proceed along with the frame. They serve as emergency exits.

b) The area should be kept clear of hazardous materials and buckets filled with sand should be kept at suitable locations.

c) All floor openings should have railings.

d) Working areas should be properly lighted.

e) Workers who are exposed to or are in danger of getting injured from flying or falling objects should be issued head-gear and they should be made to wear it.

f) The construction sites should be visited by the designers who have a thorough insight of the inherent strength requirements. A trained designer's attention will detect the potential hazards in the design more easily.

9.8 Other Precautions

Many avoidable accidents result due to the fault of operators of machinery through overwork or under the influence of alcohol. Working period of operators should reasonably be restricted and the tendency of taking intoxicating drinks during working hours should be dealt with severely.

9.9 Safe Practices

9.9.1 *Welding and Gas Cutting*

a) Welding machines should be controlled by a switch mounted on or near the machine framework, which when opened immediately cuts off the power from all conductors supplying the machine.

b) Cables should be supported so as not to create dangerous obstructions.

c) Frames of arc-welding machines should be effectively earthed.

d) Electrode holders should have adequate current carrying capacity and be adequately insulated to prevent shock, short-circuiting or flash overs.

e) Circuit connections should be waterproof.

f) Connections to welding terminals should be made at distribution boxes, socket outlets by bolted joints.

g) Electrodes and return leads should be adequately protected against damage.

h) Electric-arc welding equipment should not be left unattended with the current switches on.

j) Welding circuits should be switched off when not in use.

k) Trained workers only should do these works.

m) No combustible materials should be present within 5 m radius of the work area.

n) Clearance should be obtained from the authorities for work in explosive/ hazardous areas.

p) For electric welding/cutting/operation all electrical connections should be checked properly before commencing the welding.

q) For gas welding all precautions should be taken for safe handling of gas cylinders.

r) Suitable precautions against fire, like keeping portable fire extinguishers, fire buckets near the works spot before doing welding work be taken.

s) Workers should wear welding goggle /shields and leather gloves while doing welding.

t) Before doing welding on drums/containers which had earlier contained combustible liquid, such containers should be cleaned thoroughly and water filled upto the level of the welding work.

9.10 Guidelines of Safety Requirements to be followed at Sites of Construction Work

a) Strong and stable platform/scaffolding is required for all work above a height of 2 m. This is to be approved by the Engineer-in-charge.

b) Ladders can be used for short duration work up to maximum height of 4 m with written permission from Engineer-in-charge for operations like painting and miscellaneous works.

c) Platform and scaffolding at a height of more than 3 m should have guard rail on all open sides.

d) All personnel working in tall building should wear helmets and safety belts.

e) Personnel should not use as passage the area under overhead works. If inevitable, such areas should be guarded by safety nets and workers should use helmets.

f) In addition to the workers, supervisory staff should also wear helmets while visiting work sites.

g) Loose materials should not be kept over the scaffolding unless suitably secured.

h) Workers should not throw materials from scaffoldings.

j) Proper access should be available for going up and coming down the scaffoldings.

k) All loose materials and tools etc should be removed and brought down after the days work.

10 CONCRETE FRAMED STRUCTURE

The following operations in erection of concrete framed structure require suitable safety precautions:

a) Transportation of materials (*see* **6**),

b) Handling of materials *(see* **11**),

c) Scaffolding and formwork (*see* **9.4** and **9.5**),

d) Mixing of materials (*see* **10.1**),

e) Placement of concrete (*see* **10.2**), and

f) Removal of formwork and scaffolding (*see* **9.5.4**).

10.1 Mixing of Materials

Construction of framed structure is normally done by concrete mixers which may be tilting or non-tilting type. They may be driven by electric motors or by diesel engines depending on the location of the structure being erected.

For electric driven mixers, the wire connecting the mixers should be in good and sound condition, and the circuit-breaker should be well maintained. Earthing of electric motor should be done as per rules and specifications.

Exhaust gases of a diesel engine if inhaled for long period may cause diseases. They should be directed away from the operator. Nobody should be allowed to go under the skip. All gears and moving parts should be well guarded.

Accidents normally occur during the cleaning of mixing drum. Care should be taken to display notice, "Under Repairs" while cleaning the drum. Wire ropes operating the drum and clutches should be inspected regularly.

Good maintenance of a mixer will reduce the chances of accident.

10.2 Placement of Concrete

Concrete can be placed manually if the quantity is less, or mechanically if the quantity is large. The former method requires more workers and the use of scaffoldings. Thus, the chances of accidents are

relatively higher.

Tower cranes, mobile cranes, cable ways and hoists are used for mechanical placement of concrete. Concrete pumps are used when the height of placement is more and the quantity to be placed is huge.

10.3 Erection Equipment

10.3.1 *Cranes and Derricks*

The provisions given in **9.2.1** shall apply.

10.3.2 *Hoists*

The provisions given in **9.2.2** shall apply.

10.4 Pre-stressed Concrete Members

All tools and equipment used in pre-stressed concreting should be kept clean. The jacks should be examined for wear and tear. Wedges and temporary anchoring devices should be examined before use.

During the tensioning operation the anchors should be kept close to the anchor plates to avoid any damage if the hydraulic line fails. The pulling heads, bolts and hydraulic jack ram should be inspected for signs of deformation, failure of thread in bolts and nuts, and for diminishing cross-sections. The pump fittings should be checked periodically.

The jacks are under pressure during tensioning. Therefore, the following safety precautions are necessary:

a) Nobody should stand in line with the tensioning element or jacking equipment during the operation.
b) No one should be directly over the jacking equipment when deflecting is being done.
c) No one should stand or work behind the jacks. Shields should be put up immediately behind the pre-stressing jacks during stressing operation.

10.5 Pre-fabricated Members

Use of pre-fabricated member is becoming popular due to the ease in assembly and time saved during construction. The pre-fabrication is done at site or in the workshop depending on the size of the member and the facility available for transportation and lifting. Launching girders are normally used to place pre-fabricated girder bridges at the site. Use of cranes is also common in lifting them. If the lifting is not done properly, the member may crack. The spreader beam should be used for this purpose. No one should be allowed under the member when they are being lifted, transported or erected. The lifting wire should be tested for the double load to be handled at least once in six months. The method of assembly and erection as specified by the designer should be strictly adhered to.

11 MATERIAL HANDLING

The material handled at construction site is broadly of two types, namely, raw materials and semi-finished or finished products. The raw materials are cement, bricks, sand, stone, earth, aggregates, water, various types of steel section, pipes, electrodes, acids, oils, paints and various types of fasteners. The semi-finished or finished goods are concrete columns, trusses, rollers, gearings and equipment of all types.

The two basic aspects of material handling are the transportation and storage of material. The former requires equipment and the latter the care in storage. The transportation equipment used in handling material have been discussed in earlier clauses. Here we may confine ourselves to the care of materials. The safety precautions necessary for different materials are given below:

11.1 Acid

a) *Storage Method* — Well ventilated and cool room. Floor should be lined with acid proof material, not hard enough to damage jars which should be cock sealed with molten wax or plaster of paris or with quicklime and linseed oil.
b) *Precautions* — Keep away from paper, wood, etc. Goggles and rubber gloves to be used by staff. Retail issue should be discouraged.

11.2 Acetylene

a) *Storage Method* — The gas dissolved in acetone (solvent) under a pressure of 160kg/cm^2 is contained in cylinders. Cylinders should be stored in vertical position.
b) *Precautions* — Cylinders should be padded with coir cover and unloaded over condemned pneumatic tyres or mattresses.

11.3 Bamboo

a) *Storage Method* — Should be submerged in water.
b) *Precautions* — An insect called 'Borer' causes decay of bamboo. IS 1902 :1993 'Code of practice for preservation of bamboo and cane for non-structural purposes deals with preservation of bamboo'.

11.4 Brushes

a) *Storage Method* — Avoid moisture and insects. Keep in original cartons. Spray with insecticide.

b) *Precautions* — Very dry heat makes the bristles brittle. Darkness helps the growth of moths. Should not be stocked for more than six months.

11.5 Carbide

a) *Storage Method* — Storage of carbide in pressure above 12.7 kg/cm^2 requires license and its stocking is governed by carbide of calcium rules.

b) *Precautions* — Water or moisture coming in contact with carbide gives off accetylene gas which is highly inflammable. All fires or artificial light shall be kept away from carbide.

11.6 Casting

a) *Storage Method* — Cast iron castings improve by aging in atmospheric temperature. Steel castings may remain in open, with a coat of paint.

b) *Precautions* — It should be ensured that last iron castings do not rust.

11.7 Cells (Battery)

a) *Storage Method* — Damp and humidity cause deterioration.

b) *Precautions* — Dry cells have limited life. Stock should be controlled accordingly.

11.8 Cement, Lime and Pozzolana

a) *Handling* — Workmen handling bulk cement, lime or fine pozzolana should wear protective clothings, resperatives and goggles, etc. They should be instructed regarding the need of cleanliness to prevent dermatitis and should be advised to use hand cream, protective jelly or similar preparation for protection of the exposed skin.

b) *Storage Method* — Supplied in gunny, paper or cloth bag; gross weight being 50 kg. Should be stored in weather-tight godown.

c) *Precautions* — Dampness will cause setting.

11.9 Cloth

a) *Storage Method* — Moisture and water are harmful. The clothes should be protected from them. Woolen goods, felt, etc, should be wrapped with paper for their proper protection from moisture and water.

b) *Precautions* — Rats and white ants are destructive agents. Wooly bear, moths, silver fish are harmful for wool. Insecticide should be sprayed.

11.10 Coal

a) *Storage Method* — Should be piled in rows of stacks, preferably not over 3 m high and 30 m wide at the base, each pile being preferably not in excess of 1 500 tonnes. Clear space of 3 m is to be maintained between piles.

b) *Precautions* — Should not be stacked against wooden posts nor come in touch with hot or warm pipes or flues. Shunting pilots should not throw sparks. In case of fire, water, if not profusely used will only raise steam and heat.

11.11 Electrical Cables and Wires

a) *Storage Method* — Keep away from oil and acid.

b) *Precautions* — Drum should be kept on edge. Cable end should be sealed with solder or pitch.

11.12 Electrode

a) *Storage Method* — Dry heat and humid atmosphere to be avoided. Should be kept in original containers in cool dry place.

b) *Precautions* — Rough handling may loosen the flux coating. (Welding rods have no flux coating.)

11.13 Firebrick

a) *Storage Method* — Store inside a shed.

b) *Precautions* — Absorption of water will cause disintegration.

11.14 Glass Sheets and Plates

Storage Method — Glass edges shall be covered or otherwise protection provided to prevent hand injuries to workers passing by. Waste glass pieces should be stored or disposed off in such a manner as to avoid injuries to workmen. Workmen handling glass pieces, waste glass pieces and fibre glass should be provided with gloves for hand protection.

Further glass sheets and plates should not be stacked horizontally nor one upon the other. These should be kept upright slightly slanting.

11.15 Leather Goods

a) *Storage Method* — Wet salted hides should be kept in cool room. Dry salted hides should not be stored in wet condition. Tanned hides and finished leather should be kept in dry room.

b) *Precautions* — Turn over regularly and wipe with clean cloth, slightly moistened with cod oil.

11.16 Machined Parts

a) *Storage Method* — Castings with machined faces may be kept outside but the machined faces, particularly threaded portion and holes should be protected properly with grease, plugged where necessary. Journals should be packed with wooden slats, over a coat of paint (white lead).

b) *Precautions* — Protect from rain water coming in contact with machined surface.

11.17 Oil

a) *Storage Method* — Oil is stored in bulk in tanks either underground or over ground. It is received in tank wagons and arrangement for decanting by gravity or by pumping should be provided. In retail, oil is stored in drums marked with grade and kind of oil. Hand operated force pump may be used for retail issues. The drums are stored up horizontally.

b) *Precautions* — Dust and dirt should be avoided. Watch against leaks. If stored for a long time, viscosity changes, therefore, rapid turnover should be aimed at. Vegetable oil deteriorates by the action of light; moisture causes rancidity and hydrolysis. It should not be stocked for more than 12 months.

11.18 Oxygen

a) *Storage Method* — Oxygen in gaseous state is supplied in steel cylinder, fitted with cap over the end which houses the valve. (The pressure of filling is 132 atmospheres.) The floor of oxygen godown should be padded with earth or sand or ashes to prevent damage to cylinder. Oxygen may be supplied, through pipe, in liquid state also.

b) *Precautions* — Proper fitting or caps should be ensured to prevent leakage. Grease, oil and any combustible material should not be kept nearby. All cylinders should have coir cover to act as cushion. Violent handling must be avoided.

11.19 Paint, Varnish and Enamel

a) *Storage Method*

1) *Dry Paint* — It is not affected by climatic effects. Stiff paint contains 15 percent to 20 percent oil. If kept for more than 9 months, then top surface forms incrustation.

2) *Ready Mixed Paint* — Settling takes place after 3 months. The drums should be inverted to prevent settling.

3) *Enamel* — Improves by storage upto 2 years but after that, it has a tendency to get oxidised and thicken.

4) *Varnish* — Long storage assists in settling of impurities.

b) *Precautions* — Guard against moisture and rain. Should not be kept in stock for more than 12 months. Varnish contains spirit and is inflammable.

Each workmen handling lead based paints shall be advised to consume 1/2 l of milk per day for his personal consumption.

Buckets containing sand shall be kept ready for use in case of fire.

Fire extinguishers installed shall be of foam type.

11.20 Paper

a) *Storage Method*
Sensitised paper — Keep in dark.

b) *Precautions* — It must be used before expiry of life.

11.21 Petrol

a) *Storage Method* — Storage of petrol above 25 litres requires licence. It should be stored according to Petroleum Rules.

b) *Precautions* — Petroleum products delivered to job sites and stored there in drums shall be protected during handling to prevent loss of identification through damage to drum markings, tags, etc. Unidentifiable petroleum products may result in improper use with possible fire hazards, damage to equipment or operating failure.

Separate godown as per Petroleum Rules with the approval of Inspector of Explosives should be provided.

11.22 Pipes

a) *Storage Method* — Ends may be plugged and threads protected. Vertical stacking in conical form prevents accumulation of rain water, when kept outside. Where large quantity of storage is necessary, pipes shall be stacked on solid level sills and contained in a manner to prevent their spreading or rolling. Suitable backing shall be placed between succeeding layers to reduce the pressure and spreading of the pipes. Removal of a pipe from the pile shall be accomplished by working from end of the pipes.

b) *Precautions* — Coat of reclaimed oil (for cheapness) or any anti-corrosive material shall

be put on steel pipes. Racks fitted with steel hook with turned-up ends to prevent from rolling off shall be provided.

11.23 Rubber Goods

a) *Storage Method* — Separate godown with low room temperature (16-20°C), a fairly high humidity and complete darkness. During period of very low atmospheric humidity, that is, during dry summer, special care should be taken to maintain high humidity. Tyres should always stand on end. Tubes should be wrapped in greased paper, dusted with french chalk.

b) *Precautions* — Do not keep stock for more than 6 months. Sunlight has adverse effect through actinic rays. Keep away from grease or oil.

11.24 Steel Sections

a) *Storage Method* — Iron coming in contact with water and moisture forms 'rust', causing tiny pits on the surface, reducing effective area. Pitting and corrosion should be prevented. Oil or anti-corrosive compound may be put over the surface.

Guide ropes shall be used to prevent swinging or swaying of the load while handling reinforcement or structural steel when a crane is used.

Manual handling — Heavy steel sections and bundles shall be lifted and carried with the help of slings and tackles. Sections should not be directly carried on the shoulders.

b) *Precautions* — Rust can be removed by chemical methods or by use of abrasives. Kerosene oil is freely used to remove rust.

11.25 Tools

Storage Method — Cutting surface protected by coating with grease or spraying with plastic or dipping in paraffin solution (gloss coat). For files, greasing by mineral jelly reduced with mineral oil to suitable consistency, may be used and then wrapped with paper.

11.26 Timber Components (Tool Handles)

a) *Storage Method* — Impregnation by oil, by submerging in an oil bath heated by steam. No nails shall be allowed to protrude so as to cause any injury hazard. Atleast two men shall carry long boards and care shall be exercised at corners and cross walks.

b) *Precautions* — Coal tar is preventive for white ants. (White ants can be exterminated by Cowans process which involves inoculation of white ants with virus.)

11.27 Sand Gravel and Crushed Stones

Stockpiles of these materials shall be so located as to provide easy access for withdrawing. The minimum safe distance shall be ensured between the materials and overhead power lines.

When withdrawals are made from stockpiles no overloading shall be permitted.

12 COMPRESSED AIR

12.1 General

The civil engineering construction such as underwater operations, deep foundations and tunnel works require men to work in the compressed air. The primary hazard of working in the compressed air is that nitrogen gets dissolved in the body of the worker due to the high ambient air pressure. If the worker returns to normal atmospheric pressure too rapidly, bubbles of gas are formed in his blood circulation system as well as in the tissues. Thus a rational procedure for entry into and exit from the compressed air is of fundamental importance.

12.2 Equipment

The equipment normally used for working in the compressed air includes compressors, caissons, airlocks and diving bells. All equipments should have good construction, sound material, adequate strength and they should be properly maintained.

12.2.1 *Compressor*

The compressor supplying air to the working chamber of airlock should be designed for 0.3 m^3 fresh air per minute per person at the pressure in the chamber and not at the atmospheric pressure.The air should be filtered before it is pumped in.

Man-Lock

The minimum internal dimensions of the man-lock are shown in Fig. 4. It should be equipped with the following accessories:

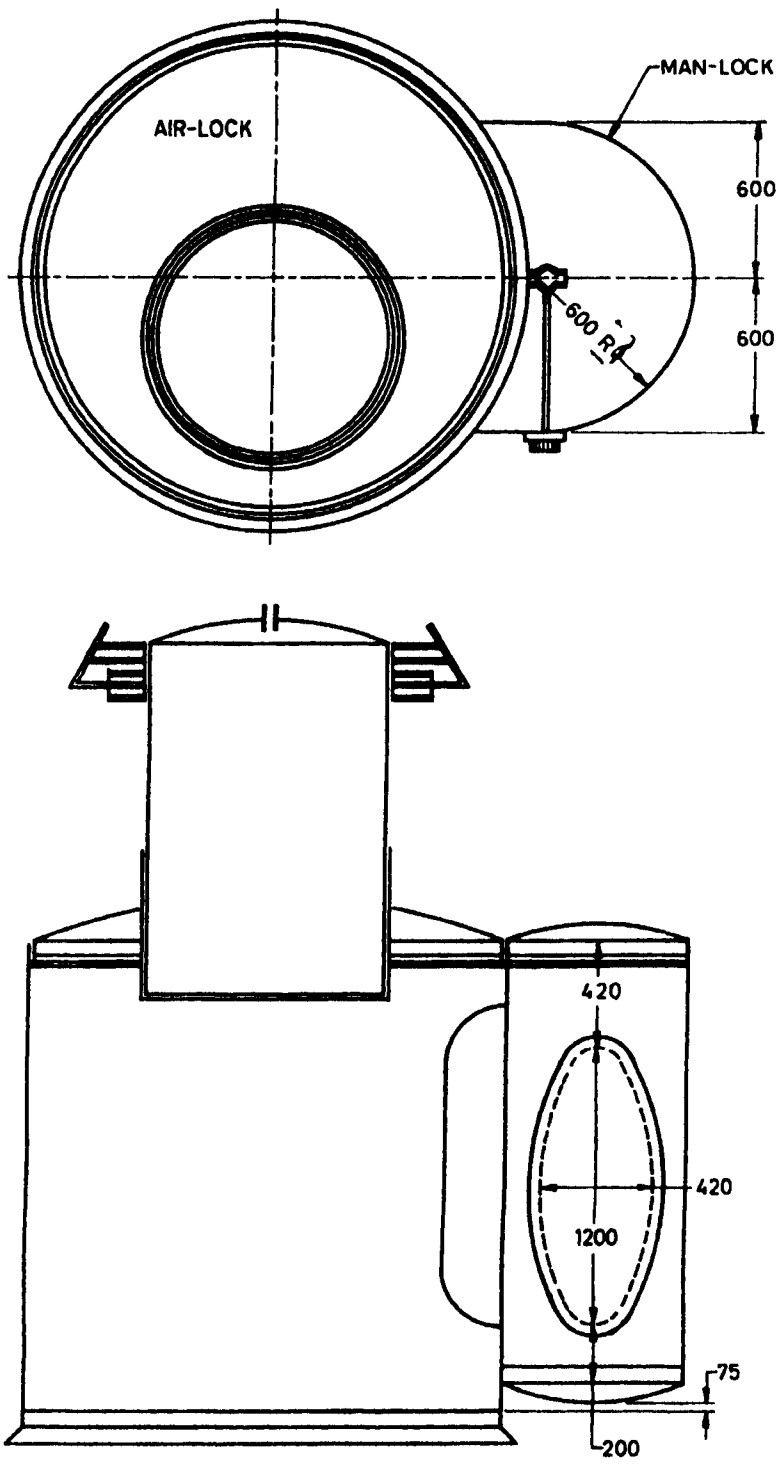
a) Accurate pressure gauges for ready indication to the man-lock attendant as well as the persons in the man-lock.

b) Time clocks suitably positioned.

c) Bells or whistles and telephone, if possible.

d) Efficient means to control the flow of air into the lock and working chamber.

All electrical installations inside the airlock should be flame-proof and the intensity of lighting should be 4.5 lux. An emergency reserve circuit powered by an independent source, such as batteries, should be available at hand.



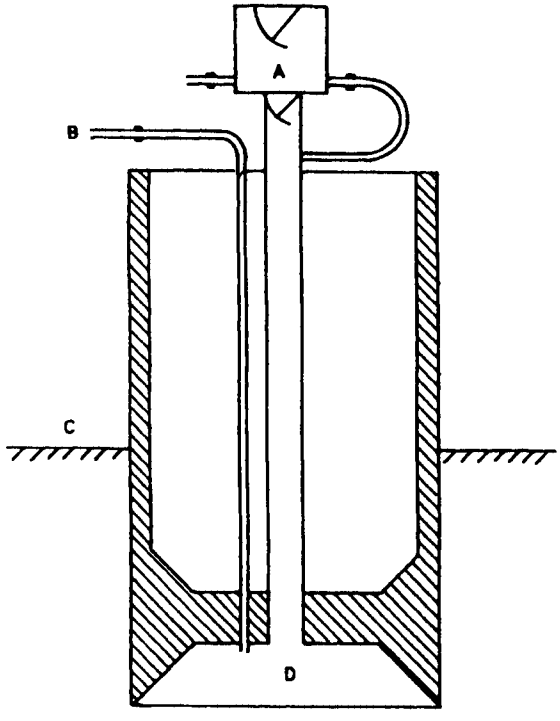
All dimensions in millimetres.

FIG. 4 TYPICAL SKETCH OF MAN-LOCK

All equipment should carry the inspection and pass certificate of the manufacturer before they are used. The pressure upto which the initial testing is carried out should be 1½ times the maximum working pressure. Thereafter, a thorough inspection should be done after every 1½ months of working, and every time it is shifted and reinstalled at another site, the inspector should certify that the equipment is in safe working condition. Record of such inspections should be maintained.

12.2.2 *Caissons*

The construction of the foundation for bridges or piers in the sea or river or work in water-bearing ground is often carried out in a caisson as shown in Fig. 5. The caisson is a tubular steel structure, open at the lower end where men work, and closed at the top. Its working chamber is supplied air at a suitable pressure through the airlock. As the material is excavated, the caisson sinks into the ground under its own weight.



A—Airlock
B—Compresed air supply
C—Water level
D—Working chamber

FIG. 5 DIAGRAM OF A CAISSON

12.3 Compression and Decompression

The compression chamber should have an airtight door, and be strong enough to withstand the pressure applied. The worker should be able to stand upright without discomfort. Its minimum head room should be 1.8 m. There should be at least 1.2 m^3 of space and 0.6 m bench seating per person working therein. Automatic pressure recorders should be fitted to all compression chambers.

Decompression should be carried out by properly trained lock keepers. The lock keeper is responsible for keeping records of all men entering the compressor chamber. Telephone link between the lock keeper and lock interior is necessary.

Except for an unforeseen emergency no person should be compressed for pressure exceeding 3.5 kg/cm^2.

Hours of work for workmen who are subjected to compression and decompression shall not be more than specified below in any consecutive 24 h.

Pressure kg/cm^2	*Number of hours excluding the period for compression and decompression*
From 0 to less than 1.25	8 (normal working)
From 1.25 to less than 2.2	6
From 2.2 to less than 3.4	4

Compression of a person in man-lock shall be carried out in accordance with requirements given in IS 4138 : 1977 'Safety code for working in compressed air (*first revision*)'.

12.4 Working Chamber

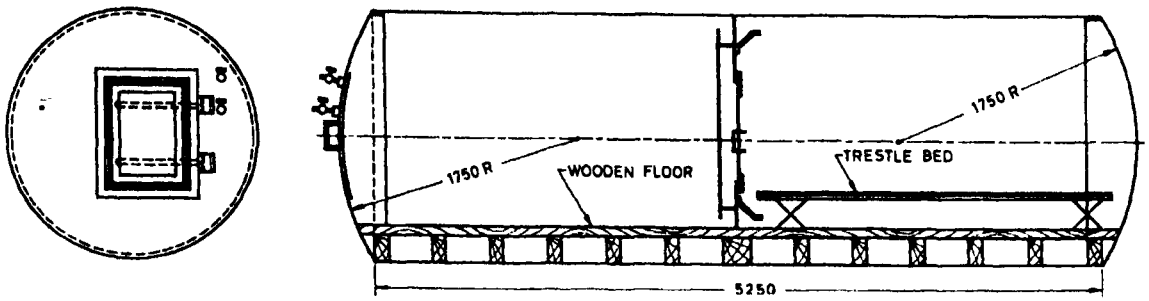
The door connecting the working chamber and the man-lock should be kept closed as far as possible. A wet bulb thermometer should be provided in every working chamber. Mercury thermometers are not to be used. The temperature of the wet bulb thermometer should not normally exceed 29°C.

12.5 Working in Compressed Air

The selection of men for the compressed air work should be done after their medical examination. The selected workers should be required to wear tags and carry identify card indicating their profession and the address of nearest decompression chamber. Persons found having infection of the upper respiratory system or who have been off work due to sickness should be medically examined and certified fit before allowing them to enter compressed air.

12.6 Medical Lock

The sketch of a typical medical lock is shown in Fig. 6. It is meant for giving treatment to persons working in compressed air where the pressure in the working chamber exceeds 1.25 kg/cm^2. However, the source of pressure should be capable of raising the air pressure in the lock from 0 to 5.27 kg/cm^2 in 5 min. The lock should have all the prescribed medical and surgical appliances and first aid boxes. Air, free from oil and carbon monoxide should be ready at hand for



All dimensions in millimetres.

FIG. 6 TYPICAL SKETCH OF MEDICAL LOCK

emergency use.

12.7 Fire Hazards

Fire is a serious hazard, particularly during welding and cutting operations in compressed air. Operators working in compressed air should wear clothes made of non-flammable fabric. Water hoses should be kept ready to spray water on welders should there be an emergency. Fire extinguishers of suitable type and pressure should also be placed at strategic points in tunnels and caissons. Only the approved type of electronic lamp, hand lamps and torches should be used. A high standard of maintenance and good house keeping helps in reducing fire hazards.

12.8 Detection of Gases

Methane and other hazardous gases may be encountered during the work in compressed air. Samples of air inside the bottom of the well as also at the top should be taken once every 8 h and tested for presence of methane and other hazardous gases, and for the deficiency of oxygen. If any such cases are found in the samples, work should be stopped immediately and the findings reported to the site in-charge for necessary action.

12.9 General Precautions

It is essential for engineers, lock keepers and medical attendants to understand the risks to which the men are exposed while working in compressed air. They should be trained to take prompt action in case a mishap occurs. The maintenance of continuous air pressure till the task is completed is a basic precaution that must be taken. For this particular reason, where electric compressors are used, a standby diesel compressor should be available.

Welding and burning may produce oxides of nitrogen or ozone. They are combustible. Therefore, only compressed air tools should be used. Electric tools should never be used. Air required for pneumatic tools should be cooled and purified in the same way as the air for working chamber.

Compressed air should not be used for cleaning purpose when something safer will do. Compressed air hose should not point on the body of any worker else the blast of compressed air can easily burst ear drum or put out an eye. Brushes may be used for cleaning the machinery, floor, clothes, etc. Particles of dust carried by compressed air may lodge under the skin unnoticed for several days and may then become infected.

Compressed air should not be used to clean equipment or parts which are contaminated with toxic materials. Eye protection guards should be used when compressed air is used and it should be ensured that persons working around are protected from the air blast and flying chips.

13 TOOLS

13.1 Electrical Tools

The commonly used electrical tools at construction sites are drills, saws and blasting machines. An electric tool comprises of three elements, that is the basic tool, the flexible cable connecting the tool to the electric supply, and supply socket into which a plug is inserted. For work of a routine nature, tools using 220-240 V are quite safe provided they are handled correctly and maintained properly. However, when work is done under humid, hot or other abnormal conditions, it is more safe to use low voltage (110V) tools.

13.1.1 *Electric Drill*

The electric drill is simple to operate. The basic safety rules for operating an electric drill are the following:

a) Hold the drill firmly with both hands during operation.

b) Use the drill for the capacity and the purpose for which it is designed.

c) Remove the plug from the socket when the tool is not in use.

d) Wear eye protectors whenever the work or the environment is likely to present hazards to the eye.

e) Report any defect in the drill immediately to the supervisor and seek advice before using it.

13.1.2 *Electric Saw*

The electric saws should be fixed, and provided with guards before operating them. If possible, the laser beam controlled stops should be provided for them so as to prevent accidents or injury to the hand. The operating instructions are the same as in the case of electric drills.

13.1.3 *Cartridges*

Cartridges operated tools provide fast and simple fastenings into concrete, steel and brickwork. They should be handled by trained and experienced workmen. They can cause many fatal or serious accidents to inexperienced workers.

There are two main types of cartridge tools:

a) High velocity where the exploding cartridge fires the fixing device down the barrel of the tool in free flight and so into the work piece.

b) Low velocity where the exploding cartridge acts on a retained piston which drives the fixing device into the work.

13.1.4 *Major Hazards*

There are three main hazards that may arise in the use of cartridge operated tools:

a) Firing through a soft material, when the fixing device punches its way right through and becomes a missile.

b) The possibility of a ricochet, when the fixing device is deflected and turns back on itself and strikes the operator or another person.

c) Splintering of the material fired into and splinters strike the operator or other worker. Secondary hazards include damaged hearing, physical strain, bruises or the operator being thrown off balance by the recoil action of the tools.

It should be remembered that the cartridge, when exploding, is a violent source of ignition. Therefore, cartridge operated tools must never be used in work areas or situations where flammable vapours are likely to be present.

13.1.5 *Avoiding the Hazards*

a) *Cartridge strength* — One of the main causes of all the hazards is the use of cartridges of a higher power than is necessary.

b) *Tool guards* — Most guards fitted to cartridge tools are sprung and the firing mechanism so arranged that the tool will not fire unless the guard is held firmly against the work piece.

c) *Personal protection* — All guards fitted are very small and consequently provide little protection in cases of splintering of the work piece. Goggles should always be worn as a secondary protection.

d) *Operating precautions* — Cartridge should not be used to fix soft material. In cases where the fix is made satisfactorily but voids or soft spots are found in the material, the operator should check the area beyond the point of work and make sure that no one is in the line of fire.

e) *Ricochet* — The most common causes of ricochet are:

1) Failure to hold the tool tightly at right angles to the work.

2) Attempting to fire into a hole already made by a failed fixing. If a fixing fails to hold, the next attempt must be at least 50 mm away.

f) *Splintering* — While the possibility of splintering is more in brittle and glazed materials, it is a hazard with concrete, brick and masonry work also. To avoid it, the fix should not be too close to the edge of a column or brick work. The 50 mm rule should again be applied and fixings kept at least that distance from any edge.

g) *Recoil hazards* — Instruction and training can virtually remove this hazard. If the operator uses the tool sufficiently to become familiar with the possible effects of the recoil before attempting to fix from a platform of any sort, then there should be no problem

h) *Misfires* — Many accidents occur because operators do not follow the correct misfire procedure. If a misfire occurs, the operator must continue to hold the tool in the firing position against the work surface, re-trigger and attempt to fire a second time. If the tool still fails to fire, it should be held firmly against the work surface for 15 s more to guard against any possibility of a slow burning primer, and then the cartridge should be removed as recommended in the manufacturer's instructions.

Any cartridge that has failed in this way should

be returned to the supplier for destruction.

j) *Storing and maintenance* — All cartridges not issued for immediate use should be stored in a cool and dry place and in a secure locked area. Their issue should be carefully controlled and kept to the minimum necessary. At the end of the work period, all cartridge tools should be cleaned and lubricated and stored away under lock and key.

13.2 Electrical Safety

Electricity is a good servant but bad master. The electrical hazards are less obvious. A live conductor appears just the same as a dead conductor. But it can give electric shocks leading to death. Again, short circuiting of the power supply can cause fire.

13.2.1 *Plugs*

The electricity supply to the tool must be drawn from the socket outlet only, into which a plug is inserted. The method of connecting a single phase power tool to electric power supply is to connect one conductor to the live phase, second to the neutral and third to the earth conductor of the consumer's installation. Always use three pin plug. Earthing of all electrical appliances is a must.

13.2.2 *Fuses*

For proper safety, connect rewirable or cartridge type fuses to the live conductor of the circuit. The heating effect of an electric current can melt the fuse and thus open the circuit. The fuse rating should not exceed twice the normal load current of the tool as indicated in the rating plate. Most of the faults that occur in plugs and fuses are due to overloading, short circuiting and faulty earthing.

These faults cause excessive current to flow, thus resulting in fuse melting and opening the circuit. The answer lies in the correct selection of fuse rating.

13.2.3 *Inspection*

Periodic inspections and preventive maintenance help in keeping the electric tools in proper operating condition. The following inspections should be carried out regularly:

a) *Ground test at 500 V* — This test should be performed with the switch on, testing from each line prong of the plug to the housing.

b) *Continuity test of the ground circuit* — This test should be performed with a continuity tester from the grounding plug to the housing.

c) *Cable* — The cable should be checked for worn or frayed spots and always replaced if found in poor condition.

d) *Brushes and commutator* — Carbon brushes should be checked and replaced if excessively worn. Commutators should be cleaned frequently and, if excessively grooved, should be turned on a lathe.

e) *Ventilating openings* — Cooling air is important to the motor operation. Ventilating openings should be cleaned if they become clogged with dust or dirt.

f) *Conductive dust* — Accumulations of carbon or other conductor material inside the motor housing can lead to shock hazards. These accumulations should be periodically blown out or wiped out.

13.2.3.1 *Problem shooting*

Problem	*Check*
a) Tool does not run	Plug, carbon brushes, electrical connection, cord, armature and /or field coils.
b) Motor overheats	Brushes, commutator, armature, field coils or ventilating openings.
c) Excessive noise	Gears and bearings.
d) Motor lacks power	Brushes, commutator, armature, field coils.

13.2.4 *Electric Installations*

a) Electrical appliances and outlets should be marked clearly to indicate their purpose and voltage.

b) Bare conductors or other bare current carrying parts of equipment should not be permitted unless adequate precautions are taken to prevent direct or indirect contact for example by fencing, screening or positioning.

c) Lamps and lamp fittings for general lighting should be installed not less than 2.5 m above the ground or floor wherever practicable.

d) Since electrical fittings are easily damaged by the rough work and severe conditions prevailing on sites, fittings should be of weather-proof type.

e) Flexible cables used for portable apparatus should have an earthing conductor.

f) All wiring should be supported on proper insulated supports and not looped/twisted over nails, etc.

g) Overhead lines should be carried on support of adequate strength and at a height that prevents contact with persons or equipment passing underneath.

h) Flexible cables should not be used to lift a portable tool.

j) Motors, switch gears and distribution apparatus should be protected against dripping and splashing water, particularly in pump rooms.

k) Fuses, motors, gears, etc, should bear clear marking of the specifications indicating their current rating and whether they are of the fast or slow braking type and as far as possible their rated braking capacity.

m) Hand lamps should be equipped with a strong cover of glass or other transparent material.

n) Portable lamp holders should have all current carrying parts enclosed with an insulated handle.

p) All electrical equipment should be inspected before it is used to ensure that it is suitable for its proposed use.

q) All conductors and equipment should be considered to be live unless there is certain proof to the contrary.

r) Temporary connections are to be given as per standard practice and should be disconnected after completing the work for which it is laid.

s) Hand lamps for use in confined spaces should be energised by 24 V supply.

13.2.5 *Electrical Works*

a) All work connected with electricity operated equipment and electric power supply should be done by a licensed electrician only.

b) All electrical work, installation, power distribution, etc, should be as per approved code and statutory regulations.

c) Motors, gears, transmission electric wiring and other dangerous part of electrically operated equipment should have safe guards for preventing free access of workers to such parts.

d) No worker should be allowed to work near any part of an electric power circuit that may be contacted in the course of his work by the worker or by his tool, inadvertently.

e) Workers employed on or near energized electrical installations should use insulating mats and tools and wear non-conductive shoes, gloves, etc.

f) All electrical supply should be considered live and precautions should be taken unless it is checked.

g) Proper warning signs should be displayed wherever live circuits exist near work area.

h) Temporary electrical connections should be taken only after getting written authorisation and should be through overhead lines.

j) All electrical equipment should be earthed properly.

k) All temporary connections should be removed and power switched off when the day's work is over and also when no operating personnel is present near the equipment.

m) Working spaces, walkways and similar areas should be kept clear of wires and cables.

n) No joints in the cable line should be used normally. In case absolute necessary, joints should be properly insulated.

13.3 Pneumatic Tools

A wide variety of compressed air tools are used on most construction sites. Compressed air is a useful source of power but has its share of hazards. The ever present hazard is the compressed air itself.

The hose must never be directed towards a person's body. The practice of workers using compressed air to dust down their clothes is extremely dangerous. It may force air into a body opening. Even a pressure as low as 103 kN/m^2 has been known to cause injury and it has been estimated that a pressure of only 27 kN/m^2 is sufficient to rupture the bowel. Eyes and ears are particularly vulnerable and many cases of foreign body in eye and perforated eardrum are reported annually.

13.3.1 *The Compressor Plant*

Most compressors used on construction sites are of mobile variety and therefore, require additional care. The supervisor should ensure that the air receiver has been examined and certified fit within the last 26 months; all moving parts are adequately guarded; clear operating instructions are displayed on the compressor; the air receiver is equipped with a safety valve and pressure gauge, the maximum safe working pressure is clearly marked, the air supply is clean and not contaminated with flammable or explosive mixtures and that the air filters are properly fitted.

13.4 Abrasive Tools

13.4.1 All moving parts of mills, mixers and disintegerators should have secure guards to avoid injury to workers. Where the abrasive element is silica, the risk of silicosis is quite high. Workers engaged on crushing, grinding or pulverising operations should be issued protective equipment and all machines covered with overall and hard material which should be kept clean.

13.4.2 *Drills*

In the use of pneumatic drills, the accidents may be caused by back twisting of the cutting tool if it gets jammed. All tools wherein the back twisting torque exceeds 15 Nm, should be equipped with additional

lateral handles. Compressed air hoses lying on the ground create tripping hazards. They should be suitably covered or hung from the ceiling.

13.4.3 *Saws*

Pneumatic saws are popular for small jobs on construction sites. They normally have inbuilt safety devices which include adjustable riving knife, guard hood, replaceable blade aperture insert, push stick and start/stop switch. These safety devices should not be tampered with by operators.

Further, the noise level during the operations of saws may exceed the safe 90 dB with prevalent frequencies above 1 000 Hz. Workers should be supplied adequate protective equipments such as earplugs or earmuffs.

13.4.4 *Screw Drivers and Impact Wrenches*

These tools are at construction sites. Their use reduces manual labour and permits predetermined torque. They should be fitted with impact valve triggering lever or nut runners. Tool manufacturers specify maximum operating pressure of 6 bar in order to prevent over pressure which may cause injury.

13.4.5 *Pneumatic Safety*

It is the responsibility of the maintenance crew to see that the tools are in safe operating condition. All rotating tools should be checked with the Tachometer for proper operating speed before accessories are attached. With the exception of cone-shaped wheels and small mounted points, all other grinding wheels should be operated under or inside the guards. The diameter of the wheel arbors should match that of the grinding wheels. The wheel washer and collar should grip the wheel firmly and the two should never be of different diameters. The nut which holds the wheel on the arbor and the washer against the wheel should be of ample size and strength.

Wheel manufacturers furnish charts giving information about the applications and speed of the various types of grinding wheels. Also most of the wheels have circular blotters around the arbor hole informing about the kind of wheel and permissible speed.

A wheel may get chipped or cracked in transportation or in storage. To check these defects, hold the wheel loosely on a finger slipped through the arbor hole and tap lightly with a wooden handle of a hammer. If the ring is clear, mount it on the arbor drawing the nut up firmly, but not so tight so as to cause fracture. To test the tool, hold it under a bench and run it; if it is fractured and failure results, reject it. If no defect is found, retest the speed of the tool and wheel with a Tachometer to be sure that it conforms to the safety Code.

13.5 Hand Tools

A large number of portable hand tools, big and small and manually operated, are used at all construction sites. Some tools may be standard while others are improvised to meet the local requirements. The improvisation should not be left to workers who need or use the tools.

Workers suggestions are welcome but any improvisation must be done only by the qualified and experienced hands who are also alive to the safety needs of workers.

13.5.1 *Hitting Tools*

The hammer is a hitting tool of varying weight, shape and size. It is normally used in a power grip but may require a precision grip for light work. For safe operations, a hammer should have a straight cylindrical handle of 24-40 mm caliber with a maximum length of 60 cm and mean maximum head weight of 6.5 to 7.5 kg. Maintenance of hammer involves that the head sound and head are firmly secured to an undamaged handle, and it can be ascertained by visual inspection. A cracked or loose head or weak handle is obviously very dangerous.

13.5.2 *Leverage Tools*

Crowbar and grafting tools are used for the following purposes:

a) Loosening compact, dense or very dense cohesionless soils.
b) Loosening soft rock or blasted rock.
c) Loosening boulders in heterogeneous deposits.
d) Excavating by underminings in firm, stiff or hard cohesive soils.

For applications given in **13.5.2** (a) and (b) the implement should be used mainly with vertical cutting action near the free edges. In the case of applications **13.5.2** (c) and (d), though the cutting action is also required, the main function is lever. The cutting edges should be adequately maintained.

13.5.3 *Cutting Tools*

Pick axes, hoes, chisels and shovels are commonly used as cutting tools on construction site. The handle of the tool should be made of strong material with adequate strength to hold the tool firmly. Accidents due to the slipping of pick axe from the handle are quite common. It is a good practice to moist the wooden handle before use during summer months.

13.5.4 *Shaping Tools*

Shaping tools include *phowrahs*, hand trowels, surface plates, files etc. They should be kept in good working order.

Accidents caused by hand tools are very common and the following factors generally cause accidents:

a) Failure to keep the tools in good serviceable condition,
b) Mismatch between the tool and the work,
c) Carelessness and wrong usage, and
d) Bad or improper storage.

The chances of injury to workmen can be minimized through proper safety supervision of workers.

13.5.5 *Other Tools*

The other tools commonly used at the construction sites are hammers, drills, chipping hammers, reverting hammers, ripping hammers, spading hammers, grinders and tipping machines. The safety precautions for these tools are similar to those mentioned in the foregoing paragraphs.

The higher speed and economy in power consumption of modern tools result in stronger mechanical oscillations which are transmitted as jerks to the workers' hands and arms. Long term exposure to vibrations, as in the case of percussion drilling may cause excessive strain in the body joints and result in occupational diseases. The frequency analysis of the vibrations transmitted by these tools has shown that the frequency between 8 Hz and 16 Hz has most harmful effects on workers health. The vibration strains can be reduced by appropriate design of the percussion mechanism, for example, damping springs, air cushions and vibration absorbing handles.

14 CONSTRUCTION MACHINERY

14.1 General Precautions

14.1.1 *Siting*

The equipment used in most construction works may be skid mounted (pump, generator), wheel mounted (mixer, compressor) or track mounted (tractor, excavator).

The stability of these equipment while working depends upon the load bearing capacity of the ground. If the load bearing capacity of the ground is likely to go down during construction due to moisture and vibration, it is safer to provide criss-cross bearing packing to avoid accidents. Generally, workers have a wrong notion that the tracked equipment does not get bogged down. This notion should be corrected. Live electric wires are a potent danger, especially in equipment with long booms. Live conductors should be de-energized before moving or operating them.

14.1.2 *Fencing*

Most bought out equipment normally have guards on the moving parts. The machinery erected at sites such as crushers, hot mix plants etc, is normally provided with guards after the erection. Due to vibrations, nuts and bolts of the machine guards may get loose, or fall down, or they may be removed by the operator. This should be checked. The guards should not be removed. Preferably, they should be tack welded in order to prevent them from being removed.

14.1.3 *Maintenance*

The maintenance crew should follow the instruction book supplied with the equipment. In particular, the equipment/engine should not be repaired when in motion. While repairing electrically operated equipment, the fuses should be removed. The tipper body, scraper apron, mixer chute, and dozer blade are some of the parts of the equipment that need frequent repairs and they also cause accidents. They should be substantially blocked or cribbed before men are permitted to work underneath.

14.2 Earth Moving Machinery

In general, all earth moving equipment have Roll Over Protective Structure (ROPS), sound suppressers, seat belts, back up alarms, warning horns, windshield wipers and easily approachable control and lever for brake system. They should be checked at the time of taking delivery. Later, they should be properly maintained.

14.2.1 *Power Shovels*

The shovels, both mechanical as well as hydraulic, need some basic precaution while being operated. The excavators should not loose their stability while operating. The manufacturers normally provide load charts for various boom lengths which should be adhered to while operating the shovel. If it is a mechanical shovel, the wire ropes should be changed after inspection as specified in the manual. The history sheet for the equipment will show the frequency for changing the wire rope and it should be followed.

For hydraulic hoses, the connections should be tight and leak-proof. The fire fighting equipment should always be provided on the hydraulic excavator.

14.2.2 *Bucket or Grab*

Buckets or grabs are the front-end equipment to base a machine. Select right type of equipment, considering such factors as the power of machine or motor, length of boom, operating radius, and total weight including the weight of bucket. Accidental dipping, tipping or swinging of a power shovel should be prevented. The bucket should always rest on the ground. The power shovel when operated near the edge of excavation or embankment should be kept at a substantial space so

as to prevent it from approaching a dangerous position. Power shovel should not be parked on a slope.

14.2.3 *Bulldozers*

The blade of the bulldozer needs inspection at least once a week. The position of the blade, while travelling up or down the gradient, needs adjustment. The blade is not designed as a brake and should not be used except in emergency.

The bulldozer should be parked on level ground, by applying brakes, lowering blade and keeping in neutral gear.

14.2.4 *Scrapers*

Ensure that the tractor driven scraper has brakes before putting it in operation. The motorized scraper should move down the hill in low gear if fitted with hydraulic retarder. The scraper bowl needs repairs and change of cutting blades occassionally. The bowl must be raised to change it. The bowl should be locked before carrying out the repairs.

14.3 Lifting and Hoisting Machinery

14.3.1 *General*

The erection of the hoisting machinery is a specialised job which should be carried out under a competent authority. The stability of crane is important as it may overturn due to bad or improper sequence of operations. The safe working load of a jib should be marked or painted on it to prevent overloading. Limit switches or electronic control should be fitted on cranes for safe lifting, swinging, turning of the load with the boom. Very often the operator is guided by a hand signal. He should be familiar with the signal system. It is a safe practice that the load to be handled is first lifted as a trial, and if successful then handled further.

14.3.2 *Tower Cranes*

Manufacturers normally give instructions for the erection or extension of tower cranes. These instructions should be followed. For fixed tower cranes, the wedge should be properly secured.

14.3.3 *Mobile Cranes*

In the case of a mobile travel crane, the specified gradient should be maintained. When the crane moves down the hill, its engine should be kept running with the gear on. The out-riggers should be used if the radius exceeds the rated load. The brakes should be 'ON' when a rubber tyred crane is operated. The pressure in the pneumatic tyre should be maintained correctly in all wheeled machines. It is advisable to equip the crane with the following accessories:

a) Anemometer to indicate wind pressure,
b) Anchors for rail mounted cranes,
c) Limiter to prevent failure of ropes,
d) Safety stops to restrict crane travel,
e) Swinging radius indicator to indicate safe load at a given radius,
f) Heel indicators to control crane heeling, and
g) Electrical/mechanical safe limits to compare the weight actually hoisted and the load admissible at various swing radii.

Annex C and Annex D give the forms for instruction of cranes and the hoist.

14.3.4 *Tips for Operating Cranes*

a) The crane should be kept on a level and firm ground. The ground should be stable. If it is soft, the area under the wheels should be made solid with stones or wooden sleepers. This also applies to the crane or crawled tracks.
b) While travelling through soft ground, the wheel track climbs better with the load behind.
c) While travelling uphill or downhill, the boom should always be kept downhill. This prevents the boom from falling back on the super structure.
d) The capacity plate should be consulted before lifting a load at a particular radius. The boom should not be raised more than 75° from horizontal. The maximum operating radius should not be exceeded.
e) Before starting operation at the beginning of the day's work, always pick up a capacity load upto 0.3 m above ground to test the drift, if any, due to faulty brakes.
f) A jerky start or stop of a fully loaded crane can overturn it or bend the boom. Also, a fast swing increases the tendency of tipping if the machine is stopped abruptly.

14.3.5 *Guy Derrick and Stiff Legs*

The guy derrick consists of a boom and a mast supported by wire rope guys. These derricks are generally used in the erection of tiered buildings. The boom of the guy derrick must be shorter than the mast, the latter supported by wire ropes and secured tightly.

The stiff leg derrick is the most versatile of derricks used in steel erection. It is essentially a mast and boom, with two sloping fixed legs to support the mast. The legs are relatively short. Stiff legs are used on yard derricks for unloading and storing materials and for bridge erection when mounted on a frame.

14.3.6 *Hoists*

Builders hoists are normally used in construction of buildings and dams. The main danger posed by them

is during erection and operation. The erection should be done carefully keeping in mind that the performance of a hoist depends on the accuracy of erection.

The capacity of a hoist is limited and it should not be exceeded. Protective clothing like gumboots, hand gloves, etc, should be used by operators. The guard rails should be provided at the openings and on the sides to prevent people from falling. The inspection of wire ropes and rails should be carried out frequently.

14.3.7 *Elevators*

In any building or plant with two or more floors or levels, vertical transportation is an essential service. People ride from floor to floor in a passenger elevator, while products move in freight elevators or special lifts. Normally elevators are annually inspected by Government Inspectors who are familiar with its maintenance and upkeep. Their instructions should be followed.

14.4 Transporting Machinery

A large number of accidents occur during the transportation of men and materials.

Trucks, tipper dumpers used on construction are normally loaded by shovels or loader. Strong canopies should be built over the driver's cabin to protect them from injuries. If the cabin is closed, it should have a system of sound and vibration suppression, seat belts, backup alarm, rear view mirror, wide windshield triplex glass, wiper, sunvisor etc. The forward control cabin is normally high. A footboard and handle should be provided for the driver's use.

Brakes and control should be designed so as to get locked when the vehicle is parked. While going down the gradient, the dynamic braking should be used instead of relying on brakes. Hydraulic retarder should be used for big size dumpers.

14.4.1 *Drivers*

Only competent and licensed persons should drive motor trucks and tractors. Competent persons holding valid driving licences for the vehicles should be engaged as drivers of the vehicles.

Trucks should be loaded at places where there is no danger of falling rock or landslide. While loading trucks with shovels, suitable distance should be kept to avoid the shovel touching the truck while loading. Brakes should be applied when a vehicle is loaded and unloaded. The vehicles should not be overloaded and the loading should be even. Stop logs should be used while tipping.

14.5 Concrete Mixers and Batching Plants

The gears of these equipments should be adequately guarded to prevent dangers. The working area of the skip should be guarded by rails so as to ensure that nobody goes there. Hoppers into which persons can fall should be guarded. The wire ropes of the mixers should be checked frequently.

14.5.1 *Concrete Vibrators*

The vibration frequency of the vibrators is likely to strain muscles of the operator if handled for a long period. Shock absorbing handles should be fitted to the vibrators. The poker should be completely inside the concrete when the vibrator is started. Excessive bending of flexible shaft should be avoided.

Electrically operated vibrators should be protected against overloads by a suitable overload relay and it should be effectively earthed. Low voltage operated vibrator with step down transformer is preferable.

14.5.2 *Road Rollers*

The roller is a compacting machine and not a transport equipment. Hence, nobody except the operator should ride on it. While moving down the hill, the roller should be in gear. After the day's work, the roller should be parked with a red light on it as a danger signal. When the roller is not in use, the parking should be on level ground with brakes on the wheels blocked.

14.5.3 *Asphalt Plant*

Accidents of burn injuries due to hot bitumen are caused due to the lack of precautions on the part of workers and supervisors. The pipes of hot bitumen should be well insulated. The plants should be inspected by a competent person and operated under his supervision. Protective clothing for the workers are essential. Adequate precautions should be taken to avoid damage from back fire. Do not use open light to ascertain the asphalt level.

14.6 Hydraulic Machines

The use of hydraulically operated equipment is now very common on construction sites. The ease of operations, better control, better breaking force has made it very popular. Unlike, cable controlled equipment, hydraulically operated equipment are more safe due to less chances of breaking cables etc.

Hydraulic pump, oil cooler, pressure relieve valves and actuating cylinders are mounted on construction equipment. The relief valves make operation safe provided they are not tampered. The hazard that are identified on these equipments are:

a) Burst of hoses, and
b) Fire.

Hydraulic fluid, if it leaks or falls on the hot part of

engine, the machine can catch fire. Hence hydraulic equipment should have a fire extinguisher on them and all hoses should be protected from external damages.

Hydraulic equipment needs skill observation. Any wrong or hasty movement of control lever can cause accident.

Hydraulic machines need good and timely maintenance. Lack of maintenance like failure of brakes, hydraulic system, etc, also results in accidents.

Hence proper training must be given to operator, mechanic etc, before they handle the equipment.

15 COMMON HAZARDS

15.1 Air Borne Contaminants

Despite general outdoor nature of work, construction workers are not immune from the hazards of airborne contaminants. Although natural wind movement will dilute dust and fumes throughout the site, operators engaged on the particular process may have dangerous concentration in their immediate breathing zones unless suitable extraction is provided. This is particularly relevant for works in shifts, tunnels and other confined spaces where forced drought ventilation may have been provided.

Certain processes commonly met in construction sites create hazardous dust and fumes.

a) Cadmium poisoning from dust and fumes arising from welding, bracing, soldering or heating cadmium plated steel.

b) Lead poisoning resulting from inhalation of lead fumes when cutting or burning structure or timber that has been protected by lead paints.

c) Carbon monoxide poisoning is caused by incomplete combustion in confined space or from the exhaust of diesel or petrol engines. Metal fumes fever is caused by breathing zinc fumes when welding galvanized steel.

d) Dust is a common nuisance on any construction site. It may arise due to the handling of earth, aggregate, cement, cleaning of stone structures, polishing and grinding of granite or terrazzo, traffic and wind. The dust inhaled by workers at construction sites may cause lung diseases like silicosis, talcosis, graphite, pneumoconiosis, etc. Further dust also has undesirable effects on equipment. It reduces the life of prime-mover and causes excessive wear on moving parts. It reduces visibility and increases chances of accidents.

Though it is not possible to totally eliminate the dust at construction site, the nuisance can be reduced in following ways:

a) Watering the haulage roads.

b) Stacking the material away from the site after studying the direction of wind.

c) Locating mixing plants in a manner that the wind carries dust away from workers and equipment.

d) Modifying the air cleaners of diesel engines.

e) Constructing dust-free flooring in the site office, store, canteen etc.

f) Good house-keeping.

15.2 Impregnation of Timber

The chemicals used for impregnation of timber are hazardous by nature and adequate precautions should be taken while using them. Wood of all types are used at construction sites. It is cut by hand or machine saws. The saw dust is dangerous if inhaled. The cholophenol salts used to preserve sawn wood is a source of skin itching, irritation of respiratory tract, headache and neurotic symptoms. The harmful effects of impregnated timber can be minimized by the following methods :

a) Wearing face masks and hand gloves.

b) Using air blowers to blow the dust away from workers.

c) Good house-keeping.

15.3 Lead Poisoning

Lead is used for its anti-corrosive property and malleability. It is added as alloys to brass, bronze and steel. Lead compounds are also used in a variety of other construction jobs. Prime hazard of lead is its toxicity. Lead poisoning may occur in human beings.

The precautions against lead poisoning is to prevent its inhalation and ingestion. Wherever possible, lead should be replaced by its alloy. Use of plastic pipes are now common in building jobs. Workers exposed to lead in any form should wear personal protective equipment, which should be washed or renewed at least once a week.

15.4 Toxic Fumes

The use of an increasing range of chemical based products on sites poses a potential health risk to those who handle them unless suitable precautions are taken. The complaint is neither infectious nor contagious but once it develops, the sufferer can become sensitised (allergic) to the particular chemical causing the complaint and will react to even smallest exposure. All chemical substances supplied at sites should carry instructions for use on the label and if the precautions recommended by the maker are followed, little ill effect should be experienced.

Barrier creams may be helpful but suffer the disadvantages of wearing off with rough usage or being washed off by water. Effective protection is provided by use of industrial gloves and where necessary aprons, face masks etc. Again, good personal hygiene is important and the use of skin conditioning creams after washing is beneficial.

Toxic fumes produced during spray painting or working with acids penetrate into human organism mainly due to inhalation. To prevent this, use of gas mask is recommended during spray painting or while working with acids etc.

15.5 Noise

Construction sites are usually noisy places. Men, machines and materials contribute to noise and unwanted sounds. The noise level beyond a certain limit may effect the ears and reduce hearing of workers. Working in noisy environment creates stress and tension in workers and reduces their output and efficiency.

Noise control is a system related problem. The noise emanates from a source and gets propagated before reaching the receiver. Therefore, the measures of noise control should attack the source of noise. Take steps to reduce its propagation and protect workers against receiving it. Machines should be fitted with noise mufflers. Workers may wear ear plugs. In extreme cases, the length of workers exposure to noise may be reduced by limiting exposure to it. Provision of noise shutters at workplaces may also help.

15.5.1 For continuous eight hour exposure, the noise level should not exceed 90 dB. For a noise level of 93 dB, the allowed exposure time would be 4 h. Other exposure times for specific noise levels to give an equivalent continuous noise level of 90 dB are as follows:

Noise Level	*Exposure Time in*
dB	h
87	18
90	8
93	4
96	2
99	1
102	1/2
105	1/4

As noise effects are cumulative the noises exposure level over a working life time should be limited to an exposure of 90 dB for a 40 h work over 30 years.

Noise exposure over 90 dB is considered excessive and requires ear protection. It is especially dangerous, should the unprotected ear be exposed to a noise level above 135 dB or with ear defender to impulse noise above 150 dB, no matter how brief the exposure time.

15.6 Vibrations

Equipment and power-driven tools generate intense vibrations that may be transmitted to workers who operate them. The vibrations may affect comfort, reduce output and cause disorders in physiological functions.

Sources of vibration transmitted to workers' hands are power-driven tools such as rock drills, pneumatic picks, chain saws, branch cutters, fettling and riveting hammers, portable grinders and polishers, nut runners, demolishing hammers, concrete breakers etc. Vibrations may be reduced through technical and organisational measures. The former comprise automation and remote control, the design of safe machines and tools by lowering the vibration parameters of the vibrating sources, by protective equipment. The latter are directed at maintaining tools and machines in a good technical condition through preventive maintenance and introducing rest periods to reduce the duration of exposure to vibration.

15.7 Power Supply

The power supply of 440 V or higher may be taken from the existing supply lines or generated on site. Electricity is the potential danger at work site and care should be taken to abide by *Indian Electric Rules.*

15.8 Lighting

Adequate and suitable lighting should be provided for all working places, approaches, dangerous openings and places where lifting or lowering is going on. Precautions should be taken against live electrical equipment on site and overhead cables.

Research has shown that artificial lighting affects the nervous system. It should be controlled in accordance with the variations of daylight. Good lighting should meet the following conditions :

a) Optimal luminance,
b) Uniform lighting,
c) Avoidance of glare,
d) Appropriate contrast,
e) Correct colour, and
f) Avoidance of flicker and stroboscope effect.

Recommended service illuminance for various class of visual task are given below:

Class of Visual Task	*Recommended Illuminance (in lux)*	*Typical Examples*
Exceptionally difficult task	2 400 or more	Inspection of minute work
Very difficult task	1 600	Extra fine work and machine work
Diffcult task	1 200	Clothing trade
	800	Fine bench and machine work
Normal range of task and work place	600	Office work with poor contrast
Moderately difficult	400	Medium bench and machine work
Ordinary	300	School room, chalk, boards, any charts.
Simple task	200	Rough bench and machine work
Rough intermittent	100	Live storage, rough and bulky material loading bays
Movement and orientation	50	Corridors with heavy traffic
Movement and orientation	20	Corridors with light traffic

15.9 Maintenance

Maintenance and safety have much in common. The maintenance personnel, by the very nature of their work, are more exposed to hazards than their fellow-workers. The potential dangers of electricity, steam, hot or greasy surface, toxic fumes etc, are the common hazards in this case. Nevertheless, the machinery and equipment need maintenance at construction sites. The office building, stores, roads and other facilities provided at construction sites also need equal attention. Good house-keeping will lessen chances of accidents.

15.10 House-Keeping

Safety is related to good house-keeping. It includes the following:

a) Working premises clean and tidy.
b) Passage ways clear of all obstructions.
c) Material well stacked and neatly placed.
d) No dangling of electric or phone wires at construction sites.
e) Roads clean, well watered and well drained.
f) Environment well lighted, particularly during the night shift.

15.11 Material

Cement stored at the site should be consumed in a reasonable time. Steel should be protected against rust. Sand, bricks and aggregates should be stacked in the outside areas. Flammable liquids like petrol, blasting powder, dynamite etc, need special precaution for storage.

Materials should be protected against effects of humidity (dampness and dryness), temperature variation, insects, heat, cold, dust and dirt.

15.12 Movement

The movement of men, materials, and machinery at sites, though necessary, should be minimal. Whatever be the method the aim should be to avoid accidents caused due to the movement.

General safety precautions in this regard are the following:

a) Ensure that an operator never tackles a load that is beyond his capacity.
b) Make full use of mechanical aids.
c) Take extra care with awkwardly shaped objects; the weight which a person can safely lift decreases as the awkwardness of the shape increases.
d) If more than one man is required to do a job, always appoint a team leader to give instructions.
e) Ensure that all necessary protective equipment is available and used.
f) Improve the underfoot conditions – Slippery sites lead to accidents.

15.13 Drowning

Fencing should be erected round any water into which persons employed are liable to fall and be drowned. Rescue equipment should be available at the sites.

15.14 Openings

Guard rails and toe-boards should be provided for any uncovered or unprotected opening, edge etc. through and from which a person is liable to fall into any liquid or material involving the risk of drowning or serious injury.

15.15 Weight

No person should unaided by another person or

mechanical device, lift by hand or carry overhead or over the back or shoulder, any material, article, tool or appliance exceeding the maximum limit in weight as set out below:

Safe Weight Limits for Lifting Task
Weight in kg

Age	18-20	20-35	35-50	Over 50
Male	23	25	20	16
Female	14	15	16	10

15.16 Occupational Health and Hygiene

The safety officer may be called upon to recommend measures to overcome health problems that have been identified by the doctor or nurse. Part of his duties may include the identification of processes and substances that are known to give rise to health risks and advising on the procedures to be followed for their safe use.

The advice he can give will be more pertinent if the safety adviser has an understanding of the nature of the substance and the manner in which it affects the functioning of the human body. Hydrocarbon solvents may affect the liver and cadmium may damage the lung or kidneys. Some health problem although not caused by the job may be aggravated by it.

15.17 Risks to Health at Work

The main hazards are of three kinds : Physical, Chemical and Biological although occupational psychological factors may also cause illness.

Physical hazards — noise, vibration, light, heat, cold, ultraviolet and infra red rays, ionising radiations.

Chemical hazards — Result of exposure to any of a wide range of chemicals. Ill effect may arise at once or a considerable period of time may elapse before signs and symptoms of diseases are noticed. By this time, the effects are often permanent.

Biological Hazards — These may occur in workers using bacteria,viruses or plants or in animal handlers and workers dealing with meat and other food. Diseases produced range from infective hepatitis in hospital workers (virus infection) to ringworm in farm labourers (fungus infection).

Cryogenics — Extreme cold is the principal hazard involved in the use of cryogenics systems and liquefied gases. Temperatures involved are in the range from –50°C to –273°C (absolute zero). Prolonged contact with the skin may cause burns similar to those resulting from contact with extreme heat. Eye protection should be worn at all times while handling these fluids because the liquid is almost always boiling and can easily splash into the user's eyes.

ANNEX A

(*Clause* 1.7.1)

MONTHLY SAFETY REPORT OF SUPERVISOR

Report No. _____

Name _____ Department _____

Period Cover : From _____ To _____

1. Inspections

Date	Hazards Located	Action Taken

Comments :

2. Meetings

	Employees			
Date	No.	Type	Subject	Remarks

Comments :

3. Accidents Investigated

Number of Accidents Investigated _____

Number of Hazards Corrected _____

Number of Recommendation to Management _____

Comments :

4. Safety Education

a) *New Workers' Orientation*

Name _____ Date _____ Name _____ Date _____

Name _____ Date _____ Name _____ Date _____

Name _____ Date _____ Name _____ Date _____

Name _____ Date _____ Name _____ Date _____

b) *Others*

Name	Date	Subject	Name	Date	Subject

5. Accident Record

Type	No. During the Month	Cumulative Total No. for the Year
a) First aid given		
b) Attended by doctor		
c) Required abstention from work		
d) Man hours worked		
e) Frequency rate		
f) Severity rate		

Comments:

_____

Signature

ANNEX B

(*Clause* 1.7.1)

WORKSHEET FOR OBSERVATION

Job Safety Observation

Employee: Supervisor:

Job Date Time

Notes on any job practices that are unsafe:

Notes on any practices that need change or improvement:

Notes on any practices that deserve complimenting:

Notes on the review and discussions:

ANNEX C

(*Clause* 14.3.3)

CERTIFICATE OF TEST AND THOROUGH EXAMINATION OF CRANE

1. Name and address of contractor responsible for the crane

2. Name and address of maker of the crane

3. Type of crane and nature of power (for example scoth derrick-manual; tower derrick-electric; rail-mounted power-electric)

4. Date of manufacture of the crane

5. Identification number:
   a) Maker's serial number
   b) Owner's distinguishing mark or number (if any)

6. Safe working load or loads	Length of Jib m (1)	Radius m (2)	Test Load (tonnes) (3)	Safe Working (tonnes) (4)
In the case of a crane with a variable operating radius (including a crane with a derricking jib or with inter-changeable jibs of different lengths) the safe working load at various radii of the jib, trolley, or crab must be given. Test loads at various radii should be given in column (3) and in the case which has been calculated without the application of a test load, 'NIL' should be entered in that column.				
7. In the case of a crane with a derricking jib or jibs, the maximum radius at which the jib or jibs may be worked (in m)				
8. Defects noted and alterations or repairs required before crane is put into service (If none enter 'None')				

I hereby certify that the crane described in this certificate was tested and thoroughly examined by me on _____ and that the above particulars are correct.

Signature _____

Qualification _____

Name and address of person, company, or association by whom the person conducting the test and examination is employed.

Date of certificate _____

ANNEX D

(*Clause* 14.3.3)

CERTIFICATE OF TEST AND THOROUGH EXAMINATION OF HOIST

Name of Contractor responsible for hoist

Address

_____

_____

_____

1. a) Type of hoist or lift and identification number and description
   b) Date of construction (if ascertainable) and, where applicable, date of last substantial alteration or substantial repair.

2. Design and construction:
   Are all parts of the hoist or lift of good mechanical construction, sound material, and adequate strength (so far as ascertainable)?

   NOTE — Details of any renewals or alterations required should be given in 5 and 6 below

3. Maintenance:
   Are the following parts of the hoist or lift properly maintained and in good working order? If not, state what defects have been found
   a) Enclosure of hoist way or lift way
   b) Leading gates and cage gate(s)
   c) Interlocks on the landing gates and cage gate(s)
   d) Other gate fastenings
   e) Cage or platform and fittings, gates, buffers, hoist way
   f) Over running devices
   g) Suspension ropes or chains and their attachments
   h) Safety gear, that is arrangements for preventing fall of platform or cage
   j) Brakes
   k) Worm or spur gearing
   m) Other electrical equipment
   n) Other parts

4. What parts (if any) were inaccessible?

5. Repairs, renewals, or alterations required to enable the hoist or lift to be used or to continue to be used with safety: a) immediately; b) within a specified time, the time is to be stated If no such repairs, renewals or alterations are required enter 'NONE'.	
6. Specify defects (other than those specified at 5 above) which require attention.	
7. If no defects requiring attention are found and no repairs, renewals, or alterations are required state that the hoist is in safe working condition.	
8. Maximum safe working load subject to repairs, renewals or alterations (if any) specified at 5.	
9. If the hoist is to be used for the carriage of passengers specify the maximum number of passengers that may be carried safely.	
10. Other observations	

I certify that on _____ I thoroughly examined this hoist or lift and that the foregoing is a correct report of the result.

Signature _____

Qualification _____

Address _____

_____

_____

Date _____

If employed by a company or association give name and address:

ANNEX E

(Foreword)

INDIAN STANDARDS FOR SAFETY IN CONSTRUCTION

IS No.	*Title*
818 : 1968	Code of practice for safety and health requirements in electric and gas welding and cutting operations (*first revision*)
875	Code of practices for design loads (other than earthquake) for buildings and structures:
(Part 3) : 1987	Wind loads (*second revision*)
(Part 4) : 1987	Snow loads (*second revision*)
(Part 5) : 1987	Special loads and load combinations (*second revision*)
930 : 1977	Wooden extension ladders for fire brigade use (*first revision*)
1197 : 1970	Code of practice for laying of rubber floors (*first revision*)
1902 : 1993	Code of practice for preservation of bamboo and cane for non-structural purposes (*first revision*)
1904 : 1986	Code of practice for design and construction of foundations in soils: General requirements (*third revision*)
1905 : 1987	Code of practice for structural use of un-reinforced masonry (*third revision*)
1989	Leather safety boots and shoes:
(Part 1) : 1986	For miners (*fourth revision*)
(Part 2) : 1986	For heavy metal industries (*fourth revision*)
2171 : 1999	Portable fire extinguishers, dry powder (cartridge type) (*third revision*)
2190 : 1992	Selection, installation and maintenance of portable first-aid fire extinguishers — Code of practice (*second revision*)
2316 : 1990	Methods of preparation of standard solutions for colorimetric and volumetric analysis (*second revision*)
2750 : 1964	Steel scaffoldings
2925 : 1984	Specification for industrial safety helmets (*second revision*)
3016 : 1982	Code of practice for fire precautions in welding and cutting operations (*first revision*)
3696	Safety code of scaffolds and ladders
(Part 1) : 1987	Scaffolds
(Part 2) : 1991	Ladders
3764 : 1992	Excavation work — Code of safety (*first revision*)
4014	Code of practice for steel tubular scaffolding:
(Part 1) : 1967	Definitions and materials
(Part 2) : 1967	Safety regulations for scaffoldings
4081 : 1986	Safety code for blasting and related drilling operations
4082 : 1996	Recommendation on stacking and storage of construction materials at site (*second revision*)
4130 : 1991	Demolition of buildings — Code of safety (*second revision*)
4138 : 1977	Safety code for working in compressed air (*first revision*)
4551 : 1968	Lifeboat crutch
4571 : 1977	Specification for aluminium extension ladders for fire brigade use (*first revision*)
4756 : 1978	Safety code for tunnelling work (*first revision*)
4770 : 1991	Rubber gloves for electrical purposes (*first revision*)
4912 : 1978	Safety requirement for floor and wall openings, railings and toe boards (*first revision*)
5121 : 1969	Safety code for piling and other deep foundation
5216 (Part 1) : 1982	Guide for safety procedures and practices in electrical work: Part 1 General (*first revision*)
5916 : 1970	Safety code for construction involving use of hot bituminous materials
5983 : 1980	Eye-protectors (*first revision*)
6194 : 1971	Intermittent positive pressure respirator, bag type, manually operated
6922 : 1973	Criteria for safety and design of structures subject to underground blasts
6994 (Part 1) : 1973	Specification for safety gloves: Part 1 Leather and cotton gloves
7205 : 1974	Safety code for erection of structural steel work
7293 : 1974	Safety code of working with construction machinery
7323 : 1994	Operation of reserviors — Guidelines (*first revision*)
7969 : 1975	Safety code for handling and storage of building material

IS No.	*Title*
8519 : 1977	Guide for selection for industrial safety equipment for body protection
8520 : 1977	Guide for selection of industrial safety equipment for eye, face and ear protection
8521 (Part 1) : 1977	Industrial safety face shields: Part 1 With plastic visor
8522 : 1977	Respirators, chemical cartridge
8523 : 1977	Respirators, canister type (gas masks)
8758 : 1993	Recommendations for fire precautionary measures in the construction of temporary structures and pandals (*first revision*)
8807 : 1978	Guide for selection of industrial safety equipment for protection of arms and hands
8940 : 1978	Code of practice for maintenance and care of industrial safety equipment for eyes and face protection
8989 : 1978	Safety code for erection of concrete frame structure
9167 : 1979	Ear protectors
9457 : 1980	Safety colours and safety signs
10245 (Part 1) : 1982	Breathing apparatus : Part 1 Closed circuit breathing apparatus (compressed oxygen cylinder)
10291 : 1982	Safety code for dress divers in civil engineering works
10386	Safety code for construction, operation and maintenance of river valley projects:
(Part 1) : 1983	General aspects
(Part 2) : 1982	Amenities, protective clothing and equipment
(Part 6) : 1983	Construction
(Part 10) : 1983	Storage, handling, detection and safety measures for gases, chemicals and flammable liquids
13415 : 1992	Code of safety for protective barriers in and around buildings
13416	Recommendations for preventive measures against hazards at work places:
(Part 1) : 1992	Falling material hazards prevention
(Part 2) : 1992	Fall prevention
(Part 3) : 1994	Disposal of debris
(Part 4) : 1994	Timber structure
(Part 5) : 1994	Fire protection
13430 : 1992	Code of practice for safety during additional construction and alteration to existing buildings
SP 7 : 1983 (Group 3)	National Building Code of India 1983 (*first revision*) Group 3 For construction engineers

ANNEX F

(Foreword)

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Amendments Issued Since Publication

Amendment No.	Date of Issue	Text Affected

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