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Handbook on Structures with Steel Portal Frames

(Without Cranes)

BUREAU OF INDIAN STANDARDS

HANDBOOK ON STRUCTURES WITH STEEL PORTAL FRAMES (WITHOUT CRANES)

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG,
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FOREWORD

The Department of Science and Technology set up an Expert Group on Housing and Construction Technology in 1972. This Group carried out in-depth studies in various areas of civil engineering and construction practices followed in the country. During the preparation of the Fifth Five-Year Plan in 1975, 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. As a result of this and on the recommendation of the Department of Science and Technology, the Planning Commission approved the following two projects which were assigned to the Bureau of Indian Standards (BIS).

a) *Project B-7* — Development Programme on Code Implementation for Building and Civil Engineering Construction; and

b) *Project B-8* — Typification of Industrial Structures

BIS has set up a Special Committee for the Implementation of Science and Technology Projects (SCIP) consisting of experts to advise and monitor the execution of these projects. A Working Group for Project B-8 under SCIP oversees the work of Project B-8.

In a developing country like India, the capital outlay under each Five-Year Plan towards setting up of industries and consequently construction of industrial buildings is very high. It is, therefore, necessary that the various parameters of industrial buildings be standardized on broad norms so that it will be feasible to easily adopt prefabricated members, particularly where repetitive structures could be used.

The standardization of parameters for industries by itself will be, no doubt, a difficult task as it will not be possible to specify the requirements of each industry. The layout including height will vary from industry to industry, for it depends on the process of manufacture and end products. However, a little more detailed analysis of the requirements indicates that the problem may not be as difficult as it appears. Although it would not be possible to specify any constraint on the parameters, a broad norm can be given within which most industries could be accommodated.

The object of Project B-8 is to typify at national level the common forms of industrial structures used in light and medium engineering industries, warehouses, workshops and process industries, and to obtain economical designs under these conditions. Even if an industrial complex is classified as heavy industry, it need not necessarily mean that all the industrial structures coming within the complex should be heavy industrial structures and that many structures could be from the typified design.

The main objective of typification of industrial structures is to reduce the variety to the minimum and provide standard prefabricated designs so that the structures could be easily mass produced and made available to the user almost off the shelf. In doing so, there will be tremendous saving in time in putting up an industry into production and hence increased production. This would indirectly increase the overall economy of the country. This would also help in the orderly use of scarce materials like steel and cement. This would be of immense use to structural engineers as well, since it would relieve them, to a large extent, from the routine and repetitive calculations. Thus the engineer's time could be used to look at more innovative and economical alternatives.

The project on typification of industrial structures involved the following three main tasks prior to preparation of typified design:

Task I — Survey and classification of industrial structures into different types;

Task II — Identification of industrial structures repeated a large number of times in the country, which are amenable for typification from the classified list prepared during Taks I; and

Task III — Specifying the elements of the industrial structures to be typified taking into consideration a number of parameters, such as structures with cranes and without cranes, span length, height, support conditions, slope of roof, wind and earthquake forces, spacing, field and shop connections, material (steel, reinforced concrete), etc.

The data regarding physical parameters like span, spacing, roof slope, column heights, crane loading, etc, of existing structures has been obtained from several public sector enterprises through Bureau of Public Enterprises (BPE). Some information from private industries has also been collected by BIS.

The typified design for the following types of industrial structures in steel and reinforced concrete is envisaged to be brought out based on appropriate Indian Standards:

a) *Steel Structures*

1) Structures with steel roof trusses (with and without cranes),

2) Structures with steel kneebraced trusses (without cranes),

3) Structures with steel portal frames (without cranes),

4) Structures with steel portal frames (with cranes), and

5) Structures with steel lattice frames (without cranes).

b) *Reinforced Concrete Structures*

1) Structures with RCC roof trusses (with and without cranes),

2) Structures with RCC portal frames (without cranes), and

3) Structures with RCC portal frames (with cranes).

In each case of structures with cranes, the maximum capacity of crane considered is limited to 20 tonnes, the normal range in light industries.

This Handbook deals with typification of structures with steel portal frames (without cranes). Typification includes analysis and design of steel portal frames using prismatic hot rolled I-sections. The portal frame has been analyzed and designed for gravity and lateral loads (wind and earthquake forces) using the moment resisting portal frame action, with pinned and fixed support alternatives.

Adequate wind bracing along the length of the building should be provided to withstand the wind on end gable and drag force on the roof and walls. Since the design for this depends upon the length of the building, locations of the expansion joint, etc, the typified design of these bracings is not given in the Handbook. However, an illustrative example of bracing design has been included.

Some of the points to be noted regarding analysis and design of these structures are as follows:

a) The typified designs have been given for the following parameters:

Span lengths (metres)	= 9, 12, 18, 24 and 30
Spacing of frames (metres)	= 4.5 and 6.0
Roof slopes	= 1 in 3, 1 in 4 and 1 in 5

Span m	*Column Height* m	*Number of Bays*			
		1	2	3	4
9.0	4.5, 6.0	*	*	*	*
12.0	4.5, 6.0, 9.0	*	*	*	*
18.0	6.0, 9.0, 12.0	*	*	*	—
24.0	9.0, 12.0	*	*	—	—
30.0	9.0, 12.0	*	—	—	—

*Combination is available.

Wind zones	= I, II and III
Earthquake zones	= I, II, III, IV and V
Type of support	= Fixed and hinged

b) The analysis of portal frames has been made using a computer programme, based on the stiffness method of analysis.

c) The structural design of hot rolled steel sections is based on IS : 800-1962. There will be some variation in the permissible stresses in case IS : 800-1984 is used. However, it is felt that the design results presented in the Handbook will not be much different from those obtained using IS : 800-1984.

d) The internal pressure/section specified in IS : 875-1964 for buildings with normal permeability ($\pm$ 0.2) has been considered in design.

e) The joint details have been included to illustrate the method of detailing and they should not be considered as the only available method for detailing.

f) The typified design results are given for purlins, girts and frame members. Design of other elements such as column base plate and fasteners, and eaves beam are also covered. Bracing and foundation designs have not been typified because of varying design parameters. However, a typical example of bracing design and footing design is included.

g) A detailed design example in the design office format is given illustrating the use of analysis and design information presented.

h) In case of frames having 24 and 30 m span lengths, results of analysis have also been presented for non-prismatic frames in which all column elements and the first rafter element adjoining the column have double the moment of inertia as compared to other rafter elements.

j) On the basis of typified designs for different spans, spacings, roof slopes, etc, some conclusions regarding the more economical designs have been covered.

k) This Handbook is intended to be used by qualified engineers only.

This Handbook is based on the work done by Structural Engineering Laboratory, Department of Civil Engineering, Indian Institute of Technology (IIT), Madras. The draft Handbook was circulated for review to Shri J. Durai Raj, New Delhi; University of Roorkee, Roorkee; National Projects Construction Corporation Limited, New Delhi; Engineer-in-Chief's Branch, Army Headquarters, New Delhi; Gammon India Limited, Bombay; Association of Consulting Engineers (India), New Delhi; Tata Consulting Engineers, Bombay; Metallurgical and Engineering Consultants (India) Limited, National Industrial Development Corporation Limited, New Delhi; Research, Designs & Standards Organization, Lucknow; S. R. Joshi and Company Limited, Bombay; Food Corporation of India, New Delhi; Engineers India Limited, New Delhi; National Hydroelectric Power Corporation Limited, New Delhi; National Thermal Power Corporation, New Delhi; Western Railways, Bombay; Braithwaite and Company Limited, Calcutta; Tata Iron and Steel Company Limited, Jamshedpur; B.G. Shirke and Company, Pune; City and Industrial Development Corporation of Maharashtra Limited, Bombay; Stup Consultants Limited, Bombay; Bharat Heavy Electricals Limited, Ranipet; Housing and Urban Development Corporation Limited, New Delhi; Hindustan Steel Works Construction Limited, Calcutta; Hindustan Prefab Limited, New Delhi; Planning Commission, New Delhi; C. R. Narayana Rao Architects and Engineers, Madras; Planning and Technology Development, Engineering Construction Corporation Limited, Madras; Central Building Research Institute, Roorkee; Jessop & Company Limited, Calcutta; National Council for Cement and Building Materials, New Delhi; Structural Engineering Research Centre, Madras; Bureau of Public Enterprises, New Delhi; Central Public Works Department (CDO), New Delhi; M. N. Dastur and Company Private Limited, Calcutta; and views received have been taken into consideration while finalizing the Handbook.

CONTENTS

1. GENERAL

1.1 Steel portal frames are one of the structural systems commonly used in industrial buildings. The lateral load resistance (due to wind, earthquake, etc) of such systems may be derived from the frame action or by means of longitudinal, lateral bracings. Steel portal frames have been designed for dead, live, wind and earthquake loads according to appropriate Indian Standards applied through the purlins and girts.

The analysis and design results are given for purlins, girts and frame members for the following parameters:

Span length (metres) = 9, 12, 18, 24 and 30

Spacing of frames (metres) = 4.5 and 6.0

Roof slope = 1 in 3, 1 in 4 and 1 in 5

Span m	*Column Height* m	*Number of Bays* 1	2	3	4
9.0	4.5, 6.0	*	*	*	*
12.0	4.5, 6.0, 9.0	*	*	*	*
18.0	6.0, 9.0, 12.0	*	*	*	—
24.0	9.0, 12.0	*	*	—	—
30.0	9.0, 12.0	*	—	—	—

*Combination is available

Wind zones = I, II and III

Earthquake zones = I, II, III, IV and V

Type of support = Fixed and hinged

The analysis and design results are presented for both fixed and hinged support conditions.

1.2 Portal Frame Configuration

Figure 1 shows the configuration of the portal frames. Purlins may be appropriately located on the rafter members subject to the maximum spacing of 1.4 m.

The joint and member numbers used in the analysis are also shown in Fig. 1.

1.3 Terminology

Bay — The space between successive bends is called a bay.

Bracing — Single or double diagonal members which form truss system with columns or beams (trusses) to provide stability and resist horizontal load.

Columns — These are members, generally vertical, which primarily resist axial load. They are more often subjected to thrust and moment. Usually rolled single sections are used but laced and battened columns are also used where two or more rolled sections are connected together by lacing or batten plates.

Column Height — It is the height of column from the top of column pedestal (or bottom of column base plate) to the eaves level of the pitched portal.

Crane Girders — These resist vertical and horizontal loads from cranes. They usually consist of an I-beam with a channel (flanges down) welded to the top flange.

Girts — Beam members carrying side sheeting and supported by columns.

Purlins — Beam members carrying roof sheeting and supported by trusses or beams.

Roof Slope — It is the slope of the roofing sheet with respect to the span length. It is obtained by dividing the height of portal frame by half the span.

Spacing between Portals — The centre line distance of two portal frames in the longitudinal direction.

Span — The centre line distance of roof columns in transverse direction.

2. PORTAL FRAME ANALYSIS

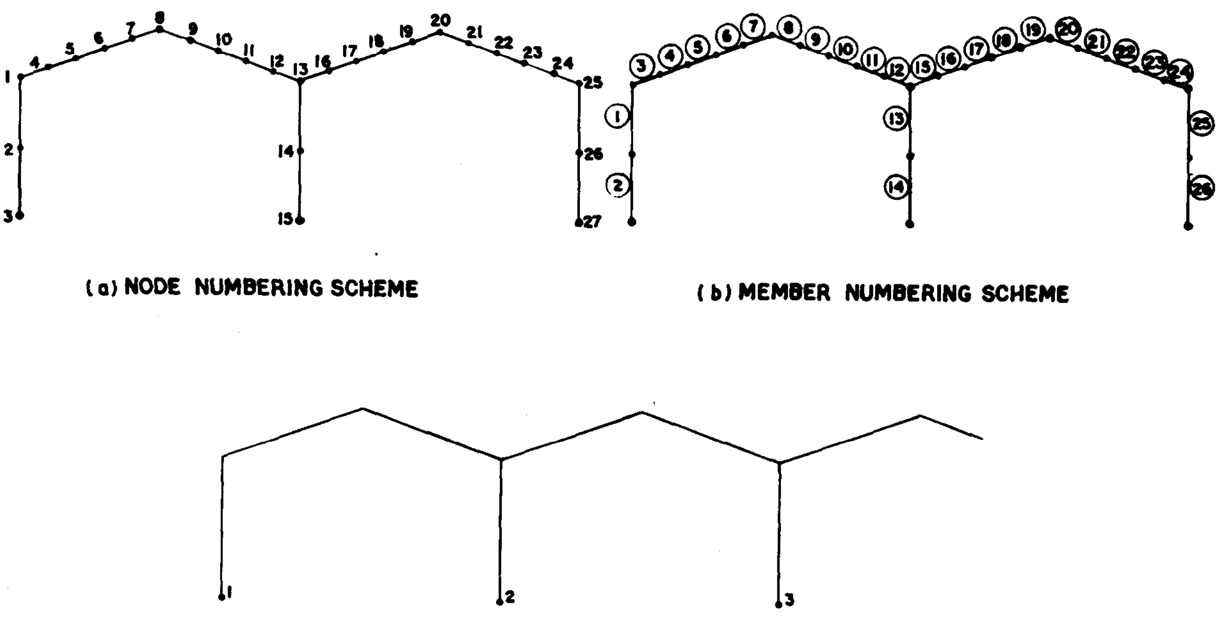
2.1 Portal frames have been analyzed for dead load, live load and wind load, and subsequently checked for earthquake load. The total dead load on the frame, excluding the column portion, varies from 40 to 60 kg/m^2. The live load has been taken on the basis of IS : 875-1964, provision for roof live loads, after reducing for roof slope and supporting member as allowed in the code. The basic wind pressure for the three wind zones have been considered as specified in IS : 875-1964. The internal pressure/suction specified in IS : 875-1964, for buildings with normal permeability ($\pm 0.2\ p$), has been included. Under each basic wind pressure, the following three different wind load conditions (*see* Fig. 2) have been analyzed:

a) wind perpendicular to ridge with internal suction (WL_1),

b) wind perpendicular to ridge with internal pressure (WL_2), and

c) wind parallel to ridge with internal pressure (WL_3).

In the analysis of multiple bay frames, drag force due to wind has also been considered according to IS : 875-1964. A few typical short and long span portal frames were analyzed for earthquake forces according to IS : 1893-1984



(a) NODE NUMBERING SCHEME

(b) MEMBER NUMBERING SCHEME

(c) FOUNDATION NUMBERING SCHEME

NOTE : In non-prismatic frame analysis, members 1,2,3,12,13,14,15,24,25,26 are assumed to be having twice the moment of inertia as compared to other remaining members.

FIG. 1 PORTAL FRAME CONFIGURATION NUMBERING SCHEMES

and it was found that earthquake forces do not govern the design. The member forces, even due to the severest earthquake, were found to be less than those due to the minimum basic wind pressure of 100 kg/m^2.

2.2 The following load combinations have been considered in calculating the design forces for beam and column in accordance with IS : 875-1964:

a) $DL + LL$,

b) 0.75 $(DL + C_n \times WL_1)$

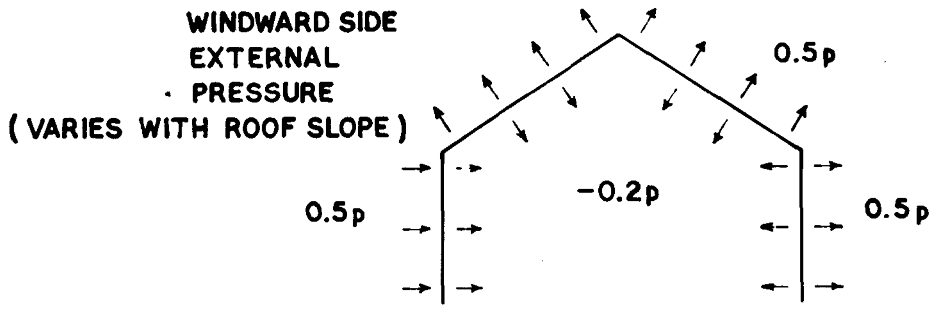
c) 0.75 $(DL + C_n \times WL_2)$

d) 0.75 $(DL + C_n \times WL_3)$

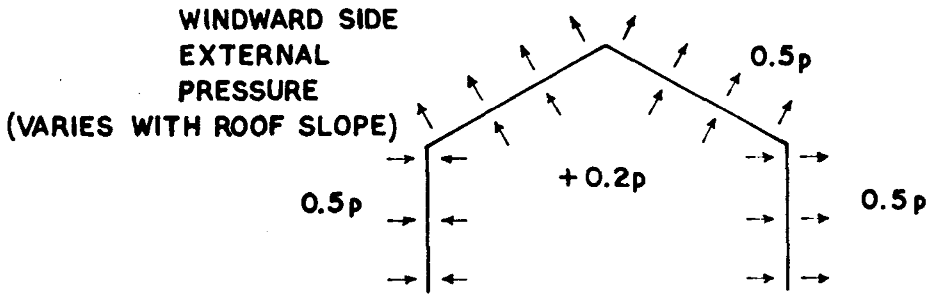
where $C_n = 0.75$ for column forces if the building height is less than or equal to 30 metres, $C_n = 0.75$ for beam forces if the height of frame is less than or equal to 10 metres and $C_n = 1.0$ for other cases. In the calculation of design forces for dead and wind load combination, the actual forces have been reduced by 25 percent to account for $33\frac{1}{3}$ percent increase in allowable stresses under this load combination.

2.3 The portal frame has been analyzed using a plane frame computer programme which is based on the stiffness method of analysis. Figure 1 gives the node and member numbering scheme used in the analysis programme. Equal moment of inertia has been assumed for both beam and column on the basis of preliminary design in the stiffness analysis. However, for frames having 24 and 30 m span lengths, additional analysis results are also presented with stiffness of column and rafter element adjacent to columns equal to twice the stiffness of the remaining rafter elements. For frames having columns and beams with the relative moment of inertia different from that assumed above, the results of analysis presented in the Handbook are not valid, and the portal frame has to be re-analyzed to get the exact design forces.

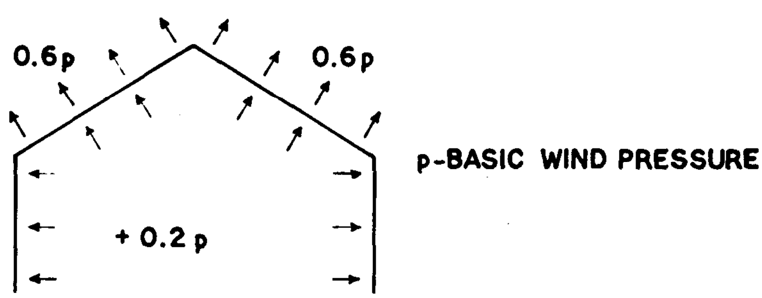
2.4 The forces due to dead and live loads have been compared with dead and wind load forces, and the maximum governing values have been presented in Table 1 to 56. The axial forces in columns do not include the side cladding weights. The maximum horizontal sway of columns has also been included in the tables to take care of the limiting deflection. The analysis results presented in the tables may be used for alternate designs as long as the final design has prismatic beam and columns having equal moment of inertia. In the case of frames having 24 and 30 m span lengths, results of analysis have also been presented in Table 57 to 68 for non-prismatic frames in which all column elements and the first rafter element adjacent to columns have double the moment of inertia as compared to other rafter elements (*see* Fig. 1).



WL1 WIND PERPENDICULAR TO RIDGE WITH INTERNAL SUCTION



WL2 WIND PERPENDICULAR TO RIDGE WITH INTERNAL PRESSURE



WL3 WIND PARALLEL TO RIDGE WITH INTERNAL PRESSURE

FIG. 2 WIND LOAD ON PORTAL FRAMES

3. DESIGN

3.0 The structures with steel portal frames using prismatic hot-rolled I-sections have been designed following the provisions of IS : 800-1962. It is felt that design results presented in the Handbook will not be much different from those obtained using IS : 800-1984.

Allowable stresses in the design are taken for hot-rolled sections and bolts according to values given for steel conforming to IS : 226-1975, IS : 2062-1980, IS : 800-1962 and IS : 3757-1972 respectively. Since forces in members due to wind load combination have been already reduced to account for increase in allowable stress, no further increase in allowable stress is considered in the design. The design assumptions and methodology of design are described below.

3.1 Purlin and Girt Design — The maximum spacing between purlins has been taken as 1.4 m and maximum spacing between girts has been taken as 1.7 m for 6 mm thick asbestos sheets laid in accordance with IS : 3007 (Part 1)-1964. The design has been done using asbestos-cement sheeting for all cladding. However, corrugated galvanized iron (CGI) sheet clading may also be used with the same spacing and size of purlin or girt. If purlins/girts are spaced farther apart to support CGI sheeting as recommended by manufacturers, the purlins and girts will have to be redesigned for additional loading. The main frame members, however, need not be changed. The purlins and girts have been designed to span between the rafters or columns spaced at 4.5 or 6.0 m and to transfer the loads (dead, live, wind and earthquake loads) from the sheeting to the supporting frame taking into consideration biaxial bending. The purlins and girts have been designed for the normal wind pressure on claddings according to IS : 875-1964 for the case of buildings with normal permeability. However, claddings and cladding fasteners have to be designed for increased wind pressure due to local effects according to IS : 875-1964. The design has been presented for tubular purlins and girts without any sag rod; and for channel purlins and girts without sag rod and alternatively with one sag rod at mid span. When sag rods are used, the diagonal sag rods are to be provided at the topmost panel, and also at every eighth panel for purlins and at every seventh panel of girts.

The typified purlins and girts sizes are as follows:

a) *Channels*

Span m	*Maximum Spacing* m	*Purlin Size* Without Sag Rod	With Sag Rod
4.5	1.4	ISMC 125 × 12.7	ISMC 100 × 9.2 ISRO 10 mm ϕ sag rods
6.0	1.4	ISMC 150 × 16.4	ISMC 125 × 12.7 ISRO 12 mm ϕ sag rods

b) *Tubes*

Span m	*Maximum Spacing* m	*Purlin Size* (*With Sag Rod*)
4.5	1.4	125 *L*
6.0	1.4	150 *L*

Girts — All the 3 wind zones

a) *Channels*

Span m	*Maximum Spacing Spacing* m	*Girt Size* Without Sag Rod	With Sag Rod
4.5	1.7	ISMC 125 × 12.7	ISMC 100 × 9.2 ISRO 10 mm ϕ sag rods
6.0	1.7	ISMC 150 × 16.4	ISMC 125 × 12.7 ISRO 12 mm ϕ sag rods

d) *Tubes*

Span	*Maximum Spacing*	*Basic Wind Pressure*	*Girt Size (Without Sag Rod)*
m	m	kg/m²	
		100	80 *L*
4.5	1.7	150	90 *L*
		200	100 *L*
		100	100 *L*
6.0	1.7	150	100 *M*
		200	125 *M*

The standard connection details of purlins and girts to the framing is shown in Fig. 3. The sag rod and diagonal sag rod details used in channel purlins and girts are given in Fig. 4. The diagonal sag rods have been designed to carry the weak axis load from 8 purlins or 7 girts as the case may be. If more purlins or girts are present in a given face, additional diagonal sag rods should be used.

NOTE — Instead of simply supported purlin and girt design given in this typified design, balanced cantilever design may also be used to get relatively economical sections. Instead of hot rolled channel and steel tubular sections used for purlins and girts, various appropriate cold-formed steel sections may also be used, if desired with appropriate sizing.

3.2 Portal Frame Design — The beam and column members of the portal frame have been designed for the maximum forces obtained from load combinations mentioned in **2**.

The effective length factors for the frame members for axial compression and bending compression have been taken as follows according to IS : 800-1962:

Member and Load	*Effective Length Factor*	
	Hinged Base	Fixed Base
Axial Compression		
Strong axis	3.0	1.5
Week axis	0.75	0.75
Bending Compression		
Columns	1.0	0.75

The maximum slenderness ratio of column has been limited to 250 since they are essentially members in bending.

The steel portal frame design results using the prismatic steel rolled I-sections are presented alongwith the analysis results in Tables 1 to 56. Each table covers all the frames having the same span, number of bays, type of support and spacing of frame but for two or three different columns heights, three roof slopes and three wind zones. In some tables, especially for column height of 9 and 12 m, design sections are not presented since single rolled I-sections of adequate strength are not available, but the analysis results are given so as to enable the user to design suitable built-up sections. For each frame, alternative sections ISLB, ISMB, ISWB and ISHB are presented and, if any particular section is not available, the next bigger section in the series may be used during structural fabrication. The maximum sway deflection for columns and the maximum vertical deflection for the beams has been limited to 1/325 of the column height and the span. In most designs, particularly in frames with taller columns, deflection limitations control the design.

3.3 Minimum Thickness of Metal — Minimum thickness of structural steel sections has been provided as 6.0 mm assuming they are fully accessible for cleaning and repainting. Where structural steel sections are not fully accessible for cleaning and repainting, thickness may be increased in accordance with IS : 800-1962.

Minimum thickness of steel tubes has been provided as 2.6 mm assuming construction is not exposed to weather and tubes are applied with one coat of zinc primer conforming to IS : 104-1979 followed by a coat of paint conforming to IS : 2074-1979 and two coats of paint conforming to IS : 123-1962. In case, the construction is exposed to weather or where regular maintenance is not possible, minimum thickness of tubes may be increased in accordance with IS : 806-1968.

4. FOUNDATION FORCES

4.1 Foundation forces are presented for both fixed and hinged base conditions. The fixed support results may be used only if the type of foundation used (pile, caisson, etc) ensures fixity at the base. Simple isolated footing located in a good stiff soil may be considered to provide fixity at the base. In all other cases, only hinged support condition shall be assumed. Foundation forces due to dead load, live load and wind load have been presented separately to facilitate the use of working stress or limit design of footing as desired by the engineer. Only the most critical value of the foundation forces from the frames having three different roof slopes (1 in 3, 1 in 4 and 1 in 5) have been presented in Tables 69 to 83. The foundation forces due to wind have been given only for a basic wind pressure of 200 kg/m². The foundation forces due to basic wind pressures of 100 or 150 kg/m² may be obtained by proportionate reduction.

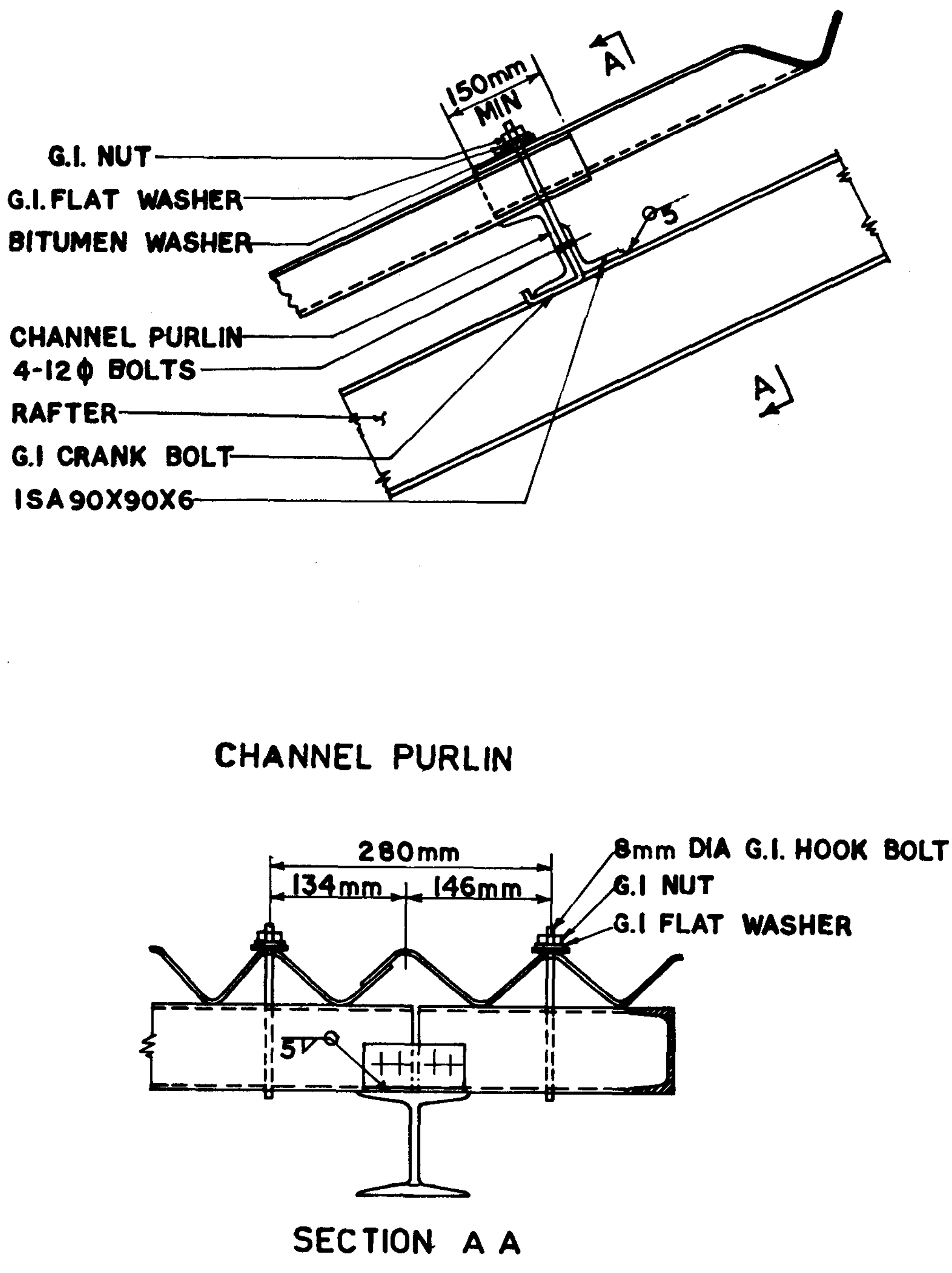


FIG. 3 PURLIN, RAFTER AND SHEETING CONNECTIONS

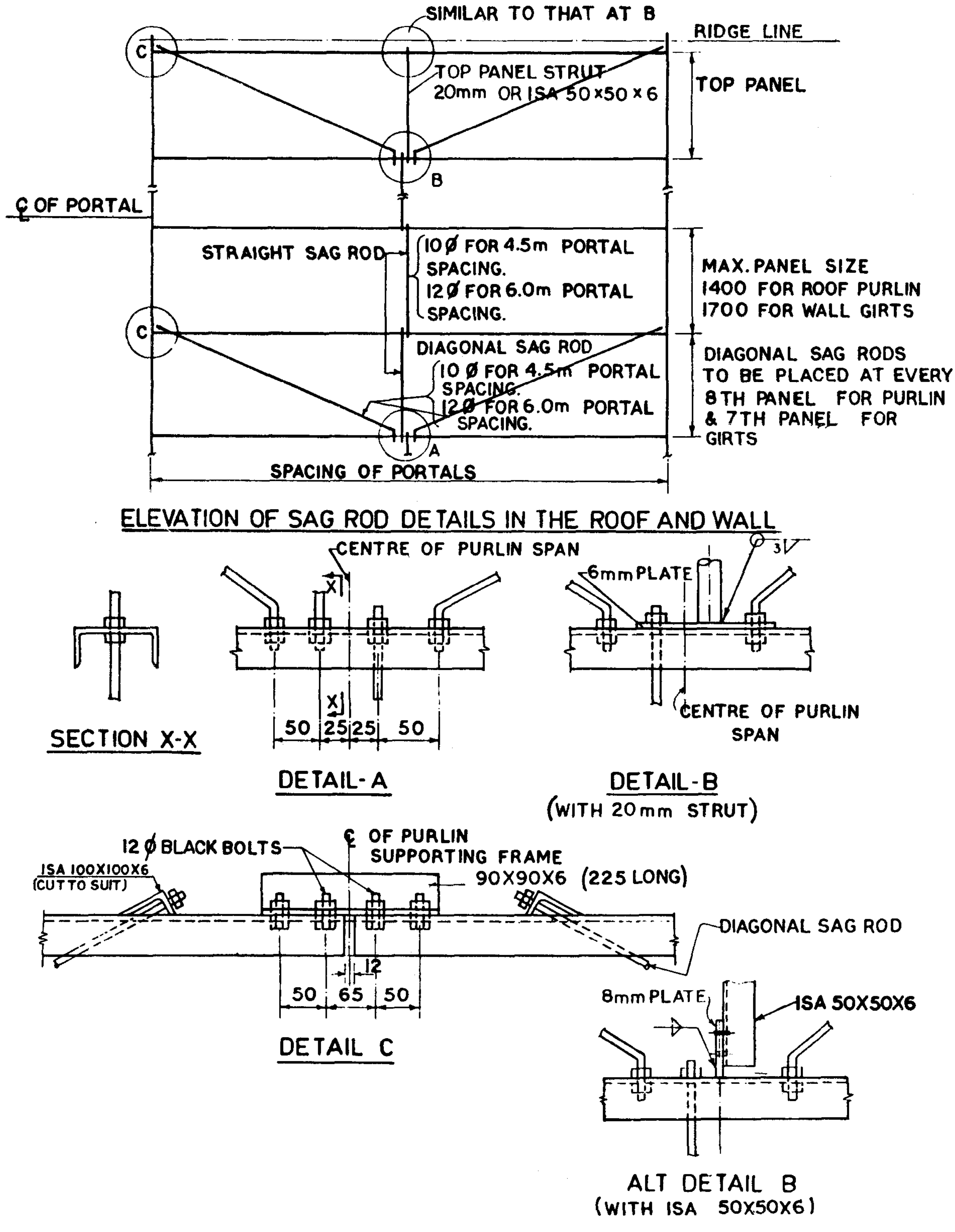


FIG. 4 SAG ROD DETAILS

Foundations supporting the frames may be designed using simple spread footings, pile foundations or caisson foundations depending upon the type of soil and type of support condition assumed in the analysis and design. A typical foundation design is shown in **6**.

5. FABRICATION DETAILS

5.0 Typical details of connections are discussed below. The details given here are by no means all encompassing or the only possible method of detailing. The end plate design procedure recommended in 'Manual of Steel Construction' has been followed more or less in the Handbook.

5.1 Purlin/Girt Connection Detail — The sheetings and the fasteners connecting sheetings to supporting members should be capable of resisting local high pressure recommended in IS : 875-1964. The connection detail between rafter and channel/ tube purlin is shown in Fig. 3. They are to be located such that the spacing between purlins does not exceed 1.4 and between girts 1.7 m in the case of AC sheets. Larger spacing may be used in case CGI sheeting is used. The purlins and girts have to be redesigned if spaced farther apart for CGI sheetings. The channel purlins and girts, continuous at the frame shall be connected with two 12 mm diameter bolts to cleat angles. Channel purlins and girts discontinuous at the frame, shall be connected to cleat angle with two 12 mm diameter bolts at each portal. The straight sag rod and diagonal sag rod details are shown in Fig. 4 as applicable to roof purlins and wall girts. In wide roofs having large number of purlins and in high wall claddings having large number of girts, the diagonal sag rods should be used at every eighth panel for purlins and at every seventh panel for girts. The top most panel close to the ridge in the roof, and the top most panel close to the eaves in the wall should have diagonal sag rods and, in addition, should support the top purlin or girt as the case may be by a strut as shown in Fig. 4.

5.2 Haunch and Crown Connection Details — The typical details of connection between column to rafter at haunch point and rafter to rafter at crown point are shown in Fig. 5 to 10. The size and length of weld and number of high tensile or HSFG bolts required are given in Table 84 to 86. Fillet weld sizes have been determined based on field strength of weld.

The splices in columns and rafters to make up the full desired length may be made using full penetration butt weld.

Eaves beams have to be provided along the length of the building at the junctions of columns and rafters. These beams have been designed so that the maximum slenderness ratio is restricted to 250. ISMB 200 and ISMB 250 sections may be used for eaves beams in frames spaced 4.5 and 6.0 m respectively. The beams may be connected to columns using one ISA $90 \times 90 \times 6$ web framing angle with 16 dia block bolts 3 and 4 numbers respectively. The beam sections and connections should also be checked for actual axial force due to wind load parallel to the ridge, transferred to the braced bay.

5.3 Column Base Details — The column base details for exterior and interior columns are shown in Fig. 11 and the sizes are given in Table 87 and 88.

5.4 Gutter Details — Typical gutter details have been presented in Fig. 12 and 13.

5.5 Expansion Joint Details — Expansion joints are not usually necessary when the building dimensions are less than 180 m. When the buildings are longer, the expansion joint is provided by constructing two different super structural support system on both sides of the joint, with the gap being properly bridged by cladding and roof sheeting.

The wind bracings and other structural systems are discontinuous across expansion joints and hence the bracing systems should be structurally independent in each segment of the structure subdivided by expansion joints.

5.6 Bracing Details — Various bracing systems are shown schematically in Fig. 14. Even though bracing may appear to be a secondary matter, it is highly important and deserves careful attention. Probably more failures, or at least unsatisfactory performances, have resulted from inadequate bracing than from deficiencies in main framing. It is apparent from Fig. 14 that the bracing in even simple structures is highly indeterminate. There can be several alternatives by which loads may be carried to the ground and in a number of bays, redundant diagonals may be used. These may be so slender, however, that they are incapable of carrying appreciable compression, which reduces the system to one in which only the tension diagonals are effective. These bracings are necessary to ensure integral behaviour of the structure and to avoid differential displacements of frames which may cause undesirable cracking of claddings. A typical example of the design of bracings is shown in **6**. Typification of bracing system has not been attempted since lot of variations are possible due to different design parameters like length of building, span, spacing, height, wind zones, etc.

The bracings in the roof along the length of the building in the panels adjacent to the eaves are provided to minimize differential movement of frames. These bracings are designed nominally based on minimum slenderness ratio.

The bracings in the roof across the building at the two end bays and necessary number of interior bays (spacing not to exceed 90 m) are provided to take care of wind loads on the gable ends and wind drag on roof due to wind parallel to the ridge. Since these bracings are not in a

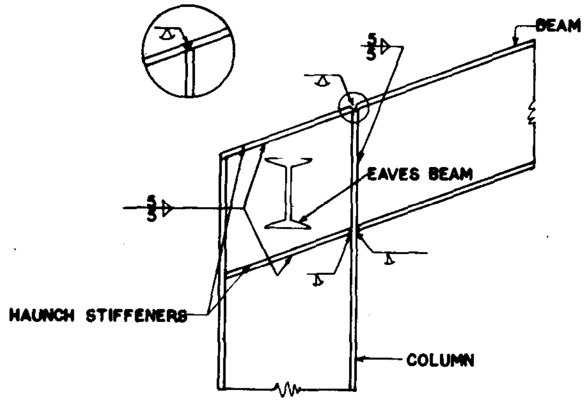


FIG. 5 EXTERIOR COLUMN AND RAFIER CONNECTION DEIAIL

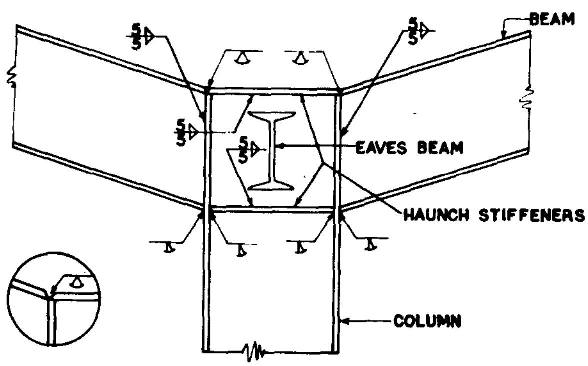


FIG. 6 INTERIOR COLUMN AND RAFIERS CONNECTION DETAIL

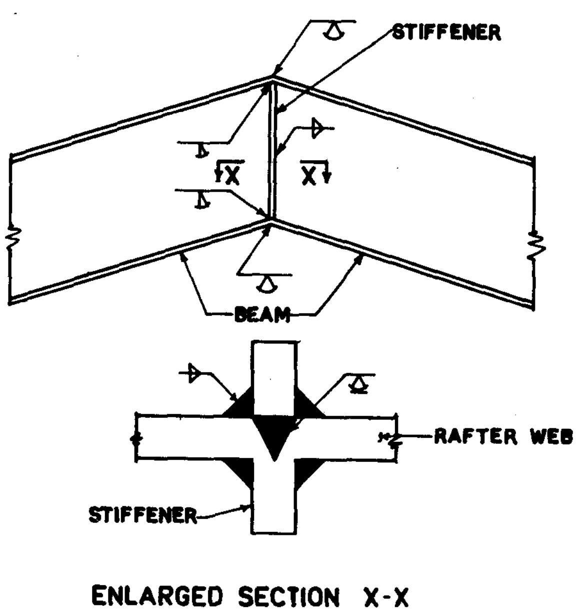
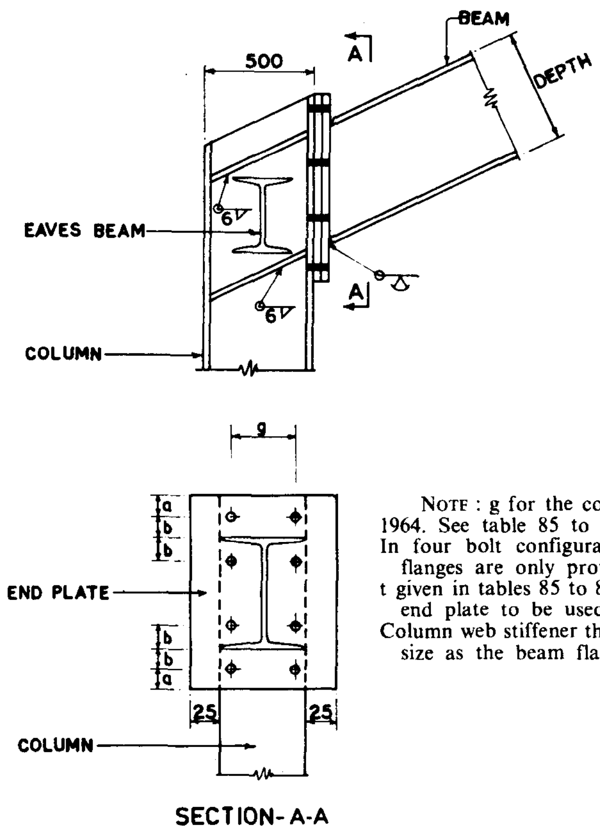


FIG. 7 CROWN DETAIL



NOTE : g for the column as given in SP : 6(1)-1964. See table 85 to 86 for other dimensions.
In four bolt configuration the bolts in between flanges are only provided.
t given in tables 85 to 86 refers to the thickness of end plate to be used.
Column web stiffener thickness shall be of the same size as the beam flange.

FIG. 8 END PLATE DETAIL AT HAUNCE

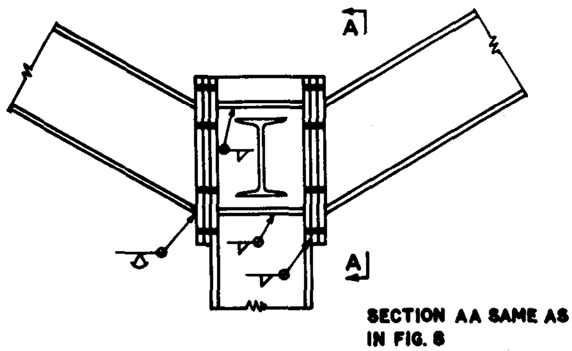


FIG. 9 END PLATE DETAIL FOR INTERIOR

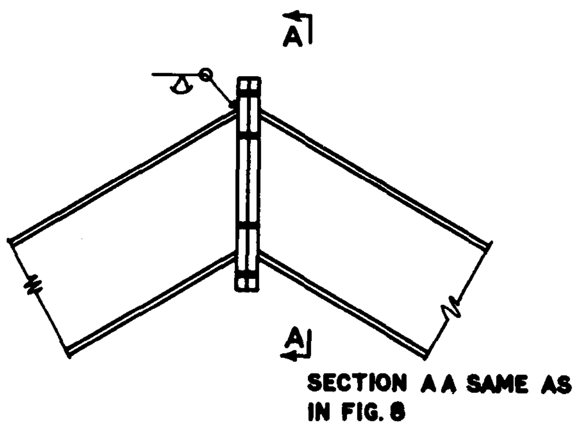
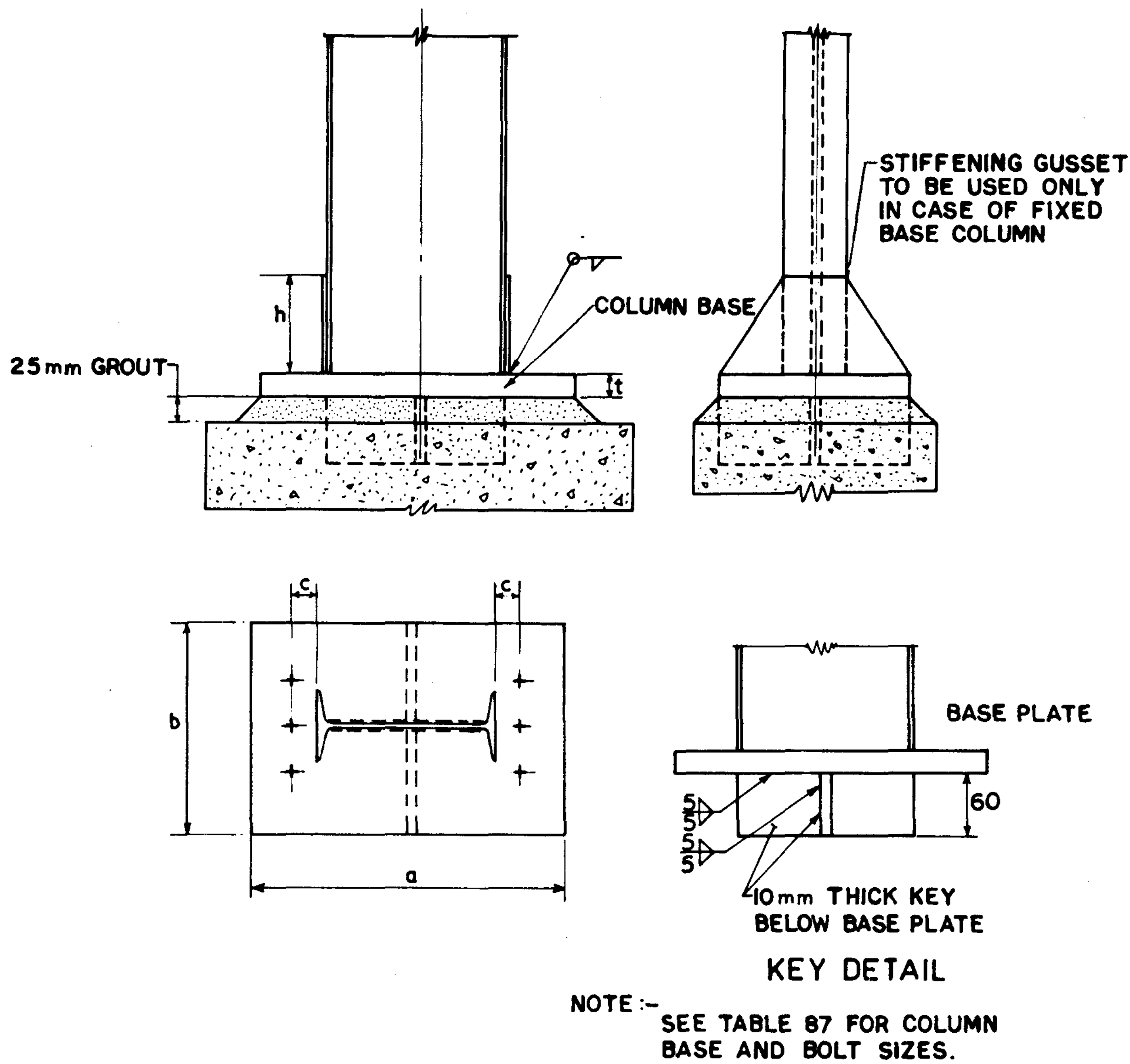


FIG. 10 END PLATE DETAIL AT THE CROWN



NOTE : See Table 87 for column base and bolt sizes.

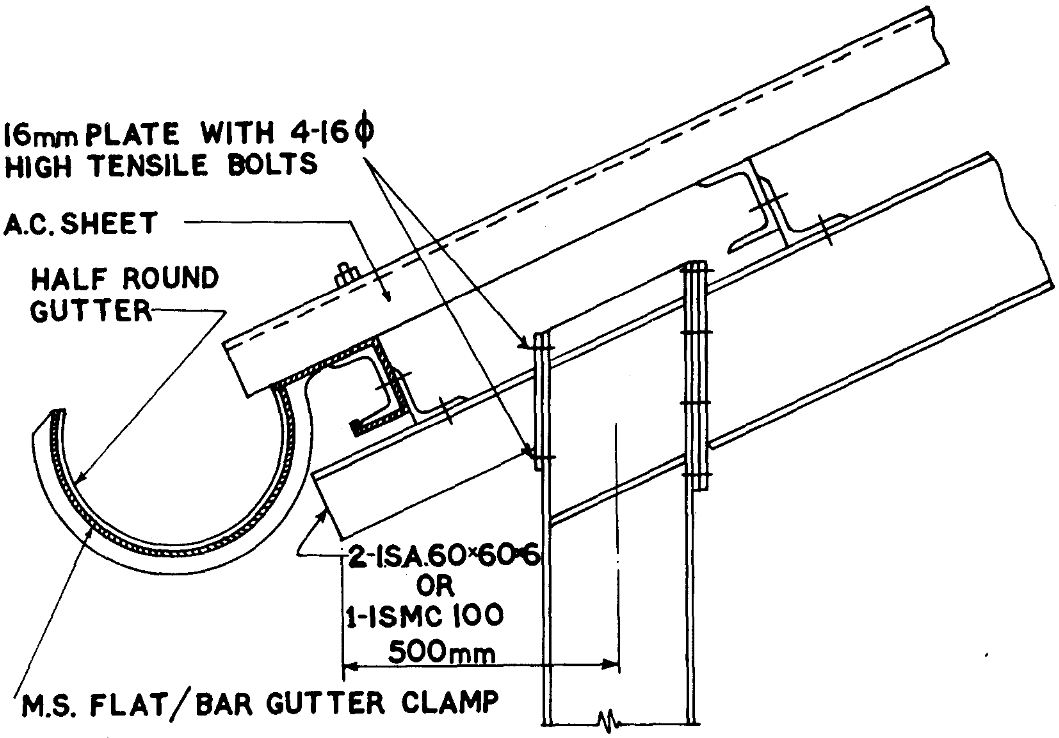
FIG. 11 FIXED COLUMN BASE DETAILS

plane but are discontinuous at the ridge, the reaction point of the bracings system and load points are not in a plane. The longitudinal bracings are to be designed to take care of this unbalanced force as shown in **6**.

The force from the cross bracings are transferred to the vertical bracings in the longitudinal walls through eaves beams. The vertical bracings in the longitudinal walls are shown for the central bay in Fig. 14. This arrangement of vertical bracings is suggested to avoid the temperature stresses which may develop if two end bays are braced as is done frequently in practice. However, if central bay bracing is utilized, temporary bracing may be necessary at the starting point of erection for the purpose of stability during erection.

Vertical bracings are usually provided also at the gable ends to give additional stiffness to the building in the transverse direction. These bracings are nominally designed based on minimum slenderness ratio.

The bottom flanges of rafter members close to the columns are in compression due to dead load and live load combination. They are not directly connected to purlin members and as much are not laterally restrained. In order to improve the lateral buckling stress of the bottom flange of rafter adjacent to columns, the end 2/5 of the



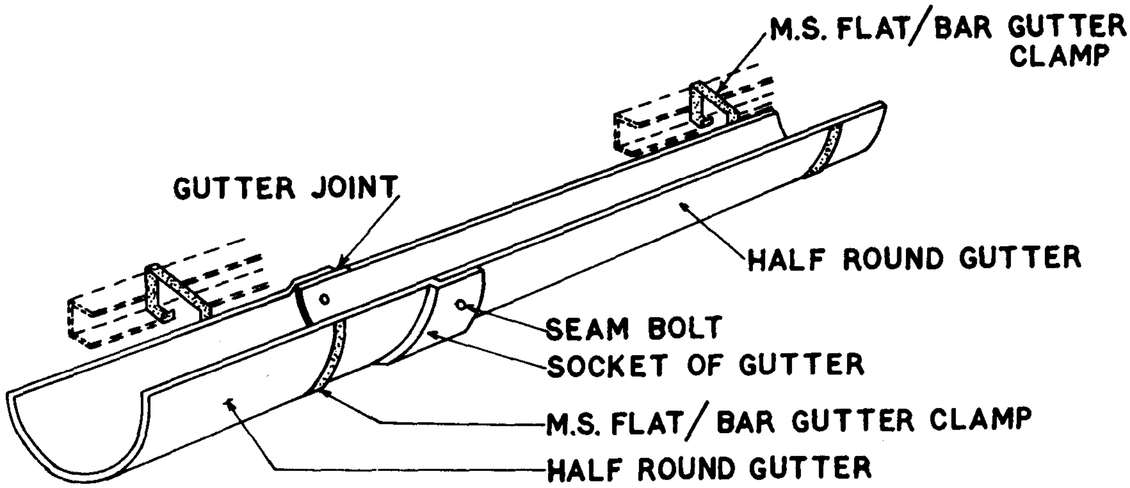


FIG. 12 GUTTER DETAILS

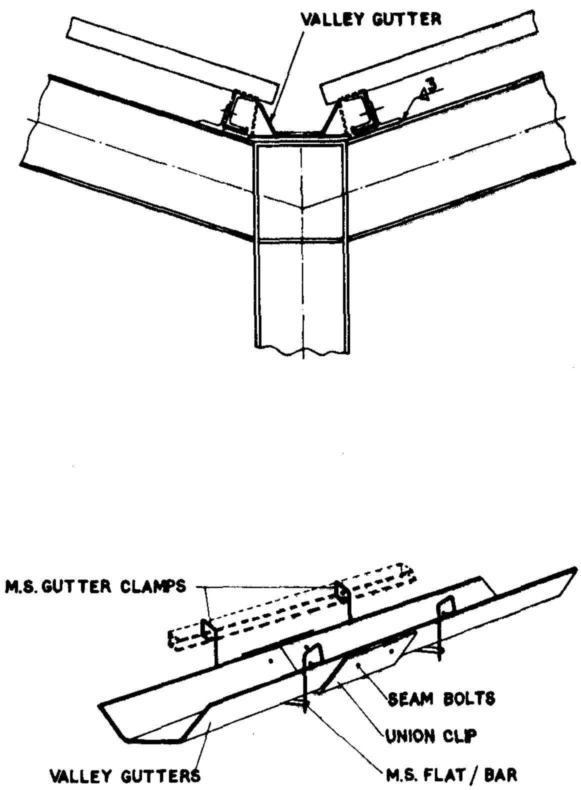


FIG. 13 VALLEY GUTTER AT JUNCTION OF TWO SLOPES

length of each rafter is connected using ISA 50 × 50 × 6 angles to the purlins at an angle of 45° to the purlin as shown in Fig. 15.

5.7 Erection Procedure — The structure with steel portal frames have to be erected taking into consideration the stability and strength of the structure during erection. Temporary bracings and other such precuations should be taken, as found necessary during construction. Recommendations of IS : 800-1984 regarding fabrication and erection shall be followed. For laying of asbestos cement sheets, recommendations of IS : 3007 (Part 1)-1964 shall be followed.

6. DESIGN EXAMPLE

6.0 Basic Parameters and Loadings — Basic parameters for analysis and design are:

Plan area	= 18.0 m × 42.0 m
Portal span	= 18.0 m
Type of support	= Hinged
Column spacing	= 6.0 m
Column height	= 6.0 m
Number of bays	= 1
Type of sheeting	= AC sheeting
Roof slope	= 1 in 3 (18.435°)
Location of building	= Hyderabad
Wind pressure	= 100 kg/m²

Assume normal permeability

Weight of roof materials (including extra weight due to overlaps and fasteners)	= 17 kg/m²
Live load	$= 75 - 2 \times (18.435° - 10°)$
	$= 58.13$ kg/m²
External windward side pressure	$= 0.7 - (0.7 - 0.4) \times \dfrac{(18.435 - 10)}{10}$
	$= 0.45\,p$

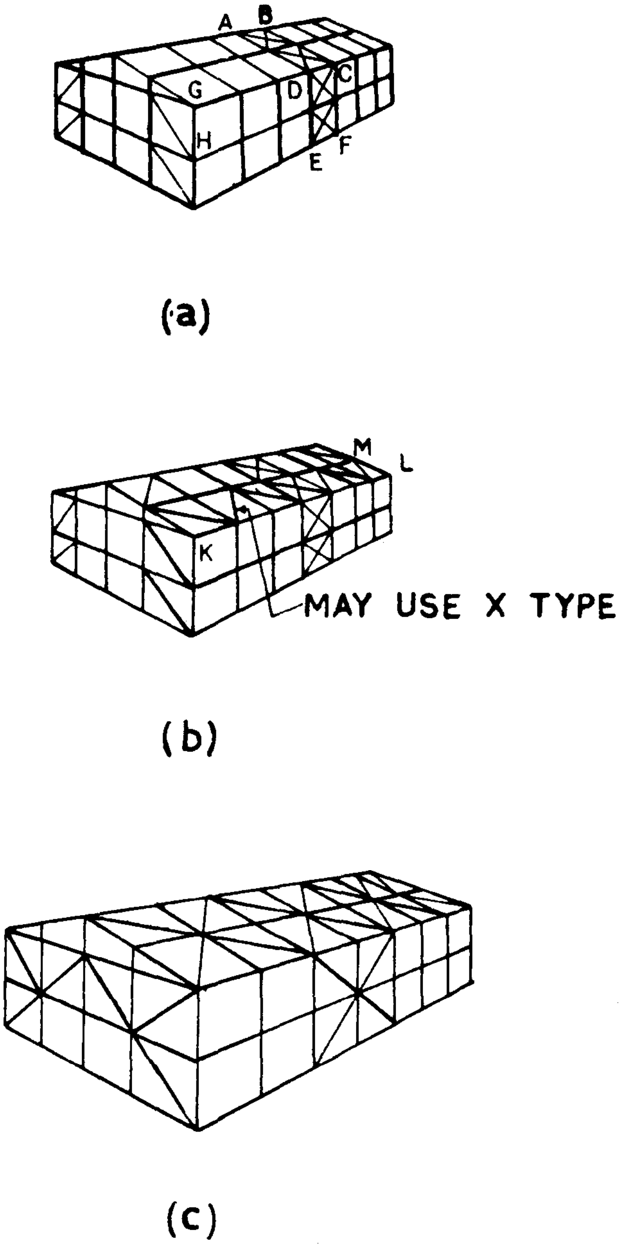


FIG. 14 BRACINGS ARRANGEMENTS

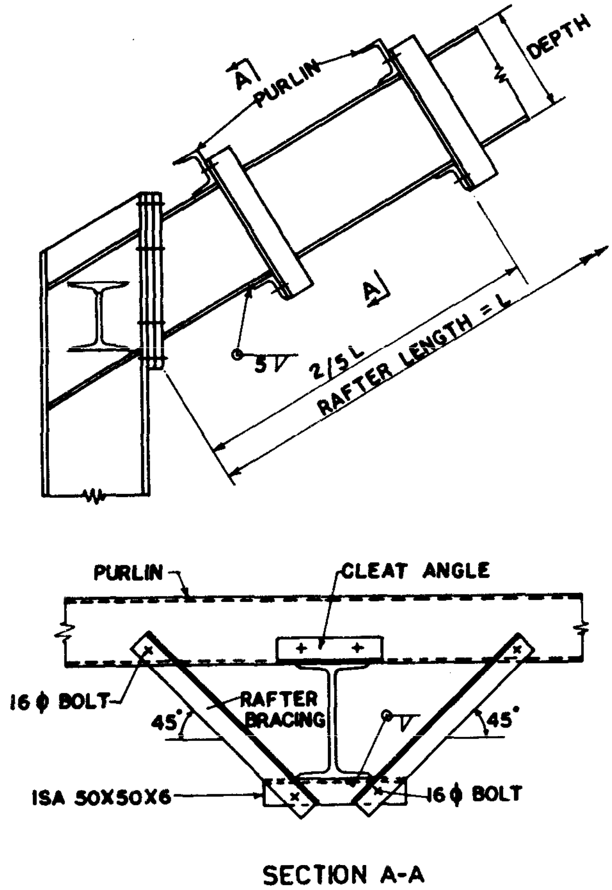


FIG. 15 RAFTER OUTSTANDING FLANGE BRACING

Wind load details are as given below:

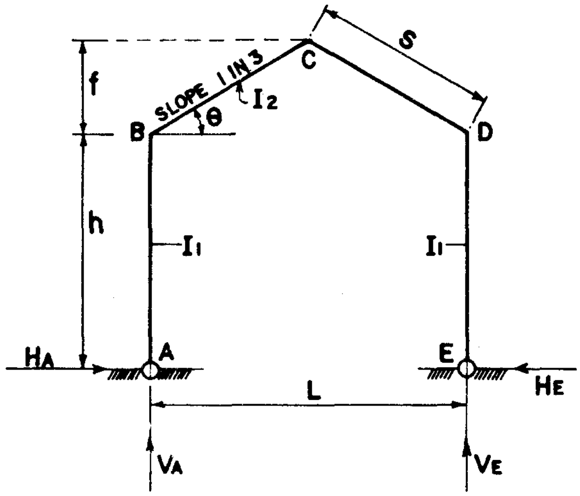
Load Case	*Wind Direction*	*Normal Permeability* kg/m²	*Wind Pressure*, kg/m² Columns Windward	Columns Leeward	Rafters Windward	Rafters Leeward
1.	Perpendicular to ridge (WL_1)	−20	70	30	−25	−30
2.	Perpendicular to ridge (WL_2)	+20	30	70	−65	−70
3.	Perallel to ridge (WL_3)	+20	20	20	−80	−80

NOTE 1 — In the case of multi-bay frames wind drag (Ref 1) has to be considered at crown points in addition to the wind pressure given in load case 1 and load case 2.

NOTE 2 — As the height of the frame is less than 10.00 metres, 25 percent reduction of wind pressure may be applied (Ref. 1).

6.1 Frame Analysis

The coefficients given in Steel Designers Manual (Ref. 9) have been used for the analysis of the portal frame.



$L = 18.0$ m

$h = 6.0$ m

$f = 3.0$ m

$S = \sqrt{9^2 + 3^2} = 9.49$ m

$\theta = 18.435°$

For column and beam ISMB 500/86.9

$I_1 = I_2 = I$

Coefficients

$$K = \frac{I_2}{I_1} \times \frac{h}{S} = \frac{I}{I} \times \frac{6}{9.49} = 0.63$$

$$\phi = \frac{f}{h} = \frac{3}{6} = 0.5$$

$$m = 1 + \phi = 1 + 0.5 = 1.5$$

$$B = 2\ (K + 1) + m = 2(0.63 + 1) + 1.5 = 4.76$$

$$C \doteq 1 + 2\ m = 1 + 2 \times 1.5 = 4$$

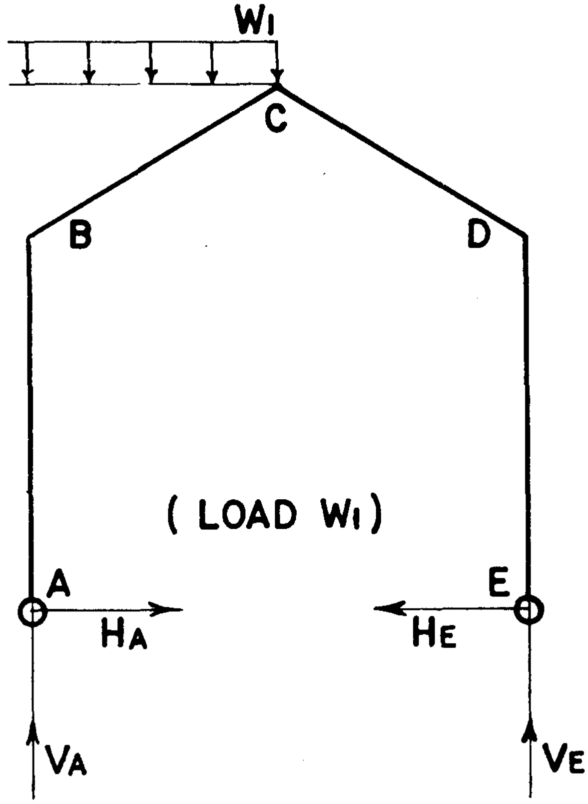
$$N \doteq B + mC = 4.76 + 1.5 \times 4 = 10.76$$

Effect of W_1

$$M_B = M_D = \frac{-W_1\, L^2 (3 + 5\, m)}{32\ N}$$

$$= \frac{-W_1 \times (18)^2\ (3 + 5 \times 1.5)}{32 \times 10.76}$$

$$= 9.88\ W_1$$



$$M_C = \frac{W_1\, L^2}{16} + mM_B$$

$$= \frac{W_1 \times 18^2}{16} - 1.5 \times 9.88\ W_1$$

$$M_C = 5.43\ W_1$$

$$H_A = H_E = \frac{-M_B}{h} = \frac{+9.88\, W_1}{6} = 1.645\ W_1$$

$$V_A = \frac{3W_1 L}{8} = \frac{3 \times 18 \times W_1}{8} = 6.75\ W_1$$

$$V_E = \frac{W_1 L}{8} = \frac{W_1 \times 18}{8} = 2.25\ W_1$$

Effect of W_2

$$\text{constant } x = \frac{\text{W}f^2\ (C + m)}{8N}$$

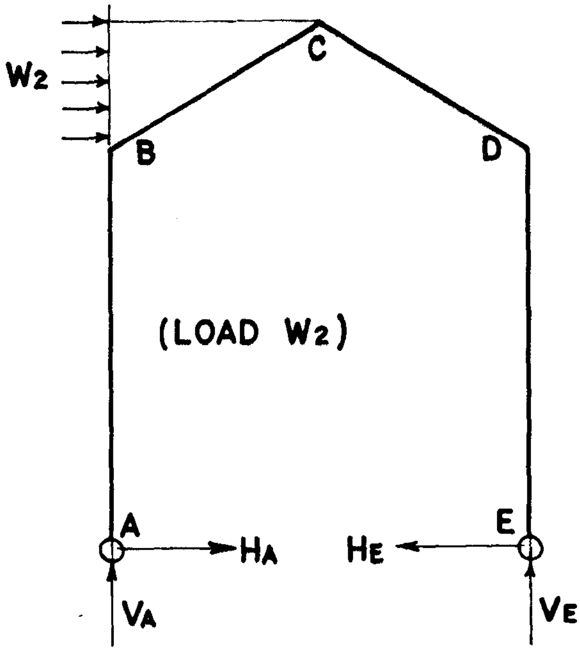
$$= \frac{W_2 3^2\ (4 + 1.5)}{8 \times 10.76} = 0.575\ W_2$$

$$M_B = +x + \frac{W_2 fh}{2} = 0.575 W_2 + \frac{W_2 \times 3 \times 6}{2}$$

$$= 9.575\ W_2$$

$$M_C = \frac{-Wf^2}{4} + mx = \frac{-W_2\, x^3}{4} + 1.5 \times 0.575\, W_2$$

$$= -1.388\ W_2$$



$$M_D = +x - \frac{Wfh}{2} = 0.575\,W_2 - \frac{W_2 \times 3 \times 6}{2}$$
$$= -8.425\ W_2$$

$$V_E = -V_A = +\frac{Wfh}{2L}(1+m)$$
$$= \frac{W_2 \times 3 \times 6}{2 \times 18}(1 + 1.5) = +1.25\ W_2$$

$$H_A = \frac{-x}{h} - \frac{Wf}{2} = \frac{-0.575\,W_2}{6} - \frac{W_2 \times 3}{2}$$
$$= -1.596\,W_2$$

$$H_E = \frac{-x}{h} + \frac{Wf}{2} = \frac{-0.575\,W_2}{6} + \frac{W_2 \times 3}{2}$$
$$= +1.404\,W_2$$

Effect of W_3

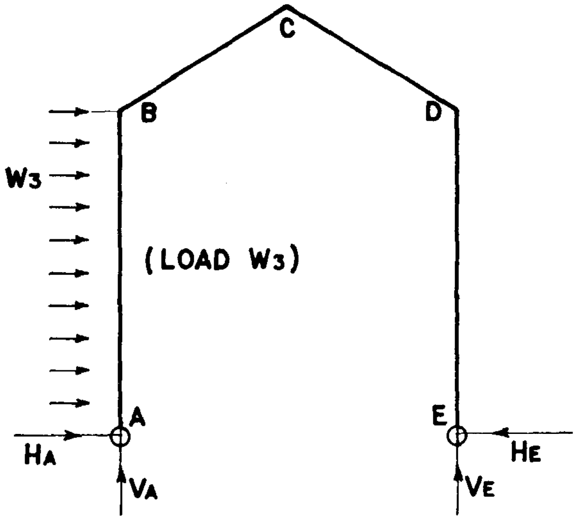
$$M_D = \frac{-Wh^2}{8} \times \frac{2(B+C)+K}{N}$$
$$= \frac{-W_3 \times 6^2}{8} \times \frac{2(4.76+4)+0.63}{10.76}$$
$$= -7.59\ W_3$$

$$M_B = \frac{Wh^2}{2} + M_D = \frac{W_3 \times 6^2}{2} - 7.59\,W_3$$
$$= 10.41\ W_3$$

$$M_C = \frac{Wh^2}{4} + mM_D = \frac{W_3 \times 6^2}{4} + 1.5 \times (-7.59)\ W_3$$
$$= -2.385\ W_3$$

$$-V_A = V_E = \frac{Wh^2}{2L} = +W_3$$

$$H_E = \frac{-M_D}{h} = +\frac{7.59\,W_3}{6} = 1.265\,W_3$$



$$H_A = -(Wh - H_E) = -(W_3 \times 6 - 1.265\,W_3)$$
$$= -4.735\,W_3$$

The summary of member forces due to these unit loads is given in Table 89.

TABLE 89 MEMBER FORCES DUE TO UNIT LOADS

(*Clause* 6.1)

Loading Case	Due to W_1	Due to W_2	Due to W_3
M_B	$-9.88\ W_1$	$9.575\ W_2$	$10.41\ W_3$
M_C	$5.43\ W_1$	$-1.388\ W_2$	$-2.385\ W_3$
M_D	$-9.88\ W_1$	$-8.425\ W_2$	$-7.59\ W_3$
V_A	$6.75\ W_1$	$-1.25\ W_2$	$-W_3$
V_E	$2.25\ W_1$	$+1.25\ W_2$	$+W_3$
H_A	$+1.645\ W_1$	$-1.596\ W_2$	$-4.735\ W_3$
H_E	$+1.645\ W_1$	$+1.404\ W_2$	$+1.265\ W_3$

Due to loads as shown in the figure (q_1 to q_6), the member forces are obtained from Table 89 as follows:

$$M_B = 10.41\,q_1 + 9.575\,q_2 - 9.88\,q_3 - 9.88\,q_4 + 8.425\,q_5 + 7.59\,q_6$$

$$M_C = -2.385\,q_1 - 1.388\,q_2 + 5.43\,q_3 + 5.43\,q_4 + 388\,q_5 + 2.385\,q_6$$

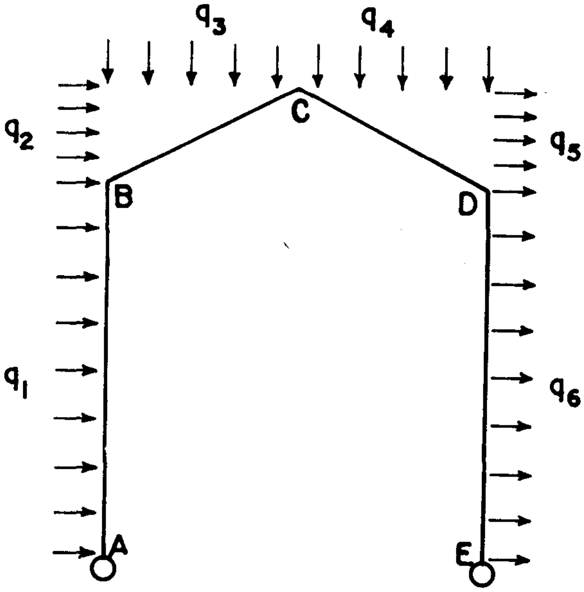
$$M_D = -7.59\,q_1 - 8.425\,q_2 - 9.88\,q_3 - 9.88\,q_4 - 9.575\,q_5 - 10.41\,q_6$$

$$V_A = -q_1 - 1.25\,q_2 + 6.75\,q_3 + 2.25\,q_4 - 1.25\,q_5 - q_6$$

$$V_E = +q_1 + 1.25\,q_2 + 2.25\,q_3 + 6.75\,q_4 + 1.25\,q_5 + q_6$$

$$H_A = -4.735\,q_1 - 1.596\,q_2 + 1.645\,q_3 + 1.645\,q_4 - 1.404\,q_5 - 1.265\,q_6$$

$$H_E = 1.265\,q_1 + 1.404\,q_2 + 1.645\,q_3 + 1.645\,q_4 + 1.596\,q_5 + 4.735\,q_6$$



Design Loads

Dead load on plan area:

$$\text{AC sheet} = \frac{6 \times 17}{\cos(18.435)} = 107.51 \text{ kg/m}$$

$$\text{Purlin} = \frac{12.7 \times 6}{1.4 \cos(18.435)} = 57.37 \text{ kg/m}$$

$$\text{Frame} = \frac{86.9}{\cos(18.435)} = 91.6 \text{ kg/m}$$

Miscellaneous = 3 kg/m

Total = 259.48 kg/m = 260 kg/m (say)

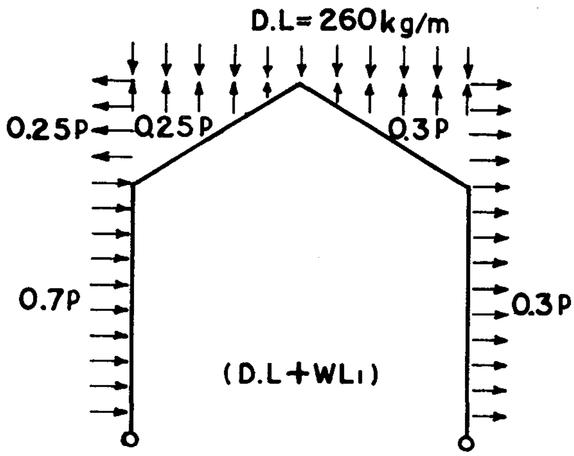
Live Load (LL)

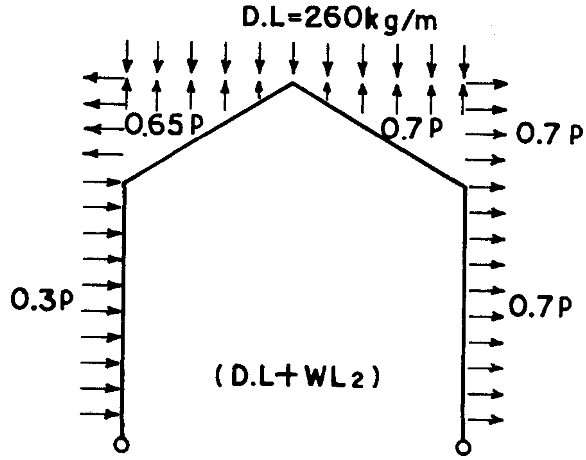
Live load (*see* Table 2 of IS : 875-1964)
= 58.13 × 2/3 × 6 = 232.52 kg/m
= 235 kg/m (say)

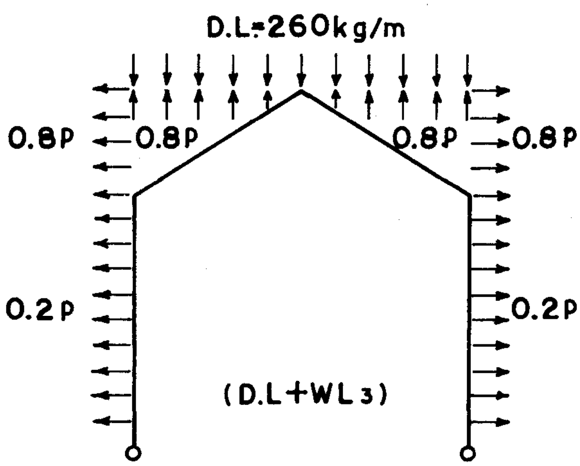
Basic wind load (Note 3a under **4.2.2**)
= 0.75 × 100 × 6 = 450 kg/m = P

The wind load on the frame for various load cases are shown below:

Forces in the frame due to the load combination as given in sketch are shown in Table 90. The values of q_1 to q_6 for each of the four load combination are also given in Table 90. It can be seen that dead load and live load combination governs the design. These values compare well with design values given in Table 34 for this frame.







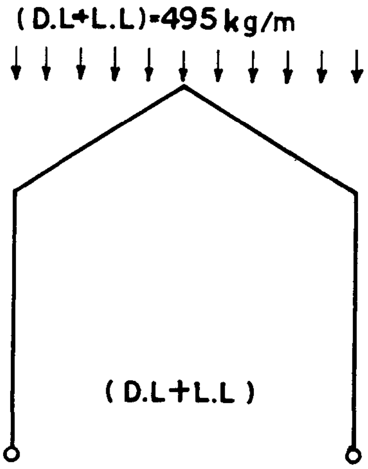
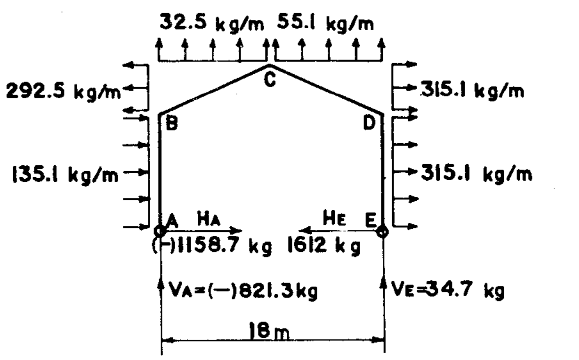


TABLE 90 DESIGN FORCES

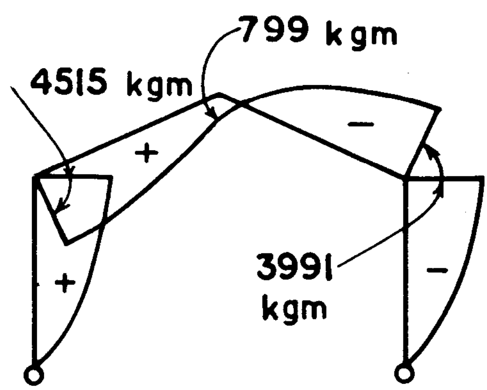
Design Forces	Loading Case			
	$DL + LL$ (kg/m)	$0.75(DL + WL_1)$ (kg/m)	$0.75(DL + WL_2)$ (kg/m)	$0.75(DL + WL_3)$ (kg/m)
	$q_3 = q_4 = 495$	$q_1 = 236.3$	$q_1 = 101.3$	$q_1 = -67.5$
	$q_1 = q_2 = 0$	$q_2 = -84.4$	$q_2 = -219.4$	$q_2 = -270$
	$q_5 = q_6 = 0$	$q_3 = 111.0$	$q_3 = -24.4$	$q_3 = -75$
		$q_4 = 93.8$	$q_4 = -41.3$	$q_4 = -75$
		$q_5 = 101.3$	$q_5 = 236.3$	$q_5 = 270$
		$q_6 = 101.3$	$q_6 = 236.3$	$q_6 = 67.5$
M_B (kg/m)	−9 781	1 254	3 386	981
M_C (kg/m)	5 376	1 046	599	258
M_D (kg/m)	−9 781	−5 125	−2 993	981
V_A (kg)	4 455	599	−616	−675
V_E (kg)	4 455	1 240	26	−675
H_A (kg)	1 629	−918	−869	42
H_E (kg)	1 629	1 158	1 209	42

Deflection Calculation

The maximum deflection in the frame occurs at joint D due to $DL + WL_2$ load case. Unit load method is used to obtain the deflection under this load. The unit load bending moment diagram (m) is given for the reduced structure with hinge at node B.

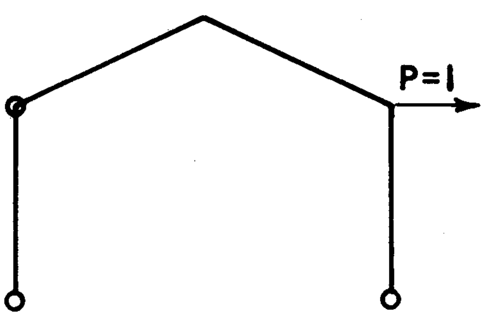


ACTUAL LOADING = LOAD FROM TABLE 8X1.333



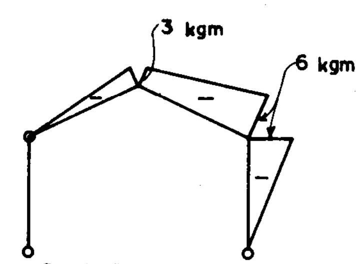
MOMENT DIAGRAM

(DUE TO ACTUAL LOAD)



Horizontal deflection at D.

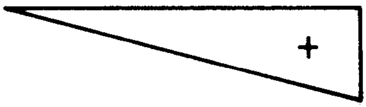
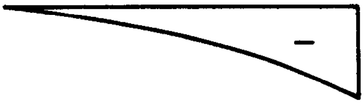
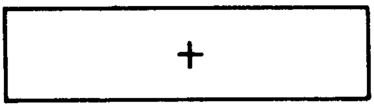
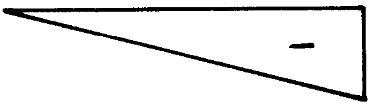
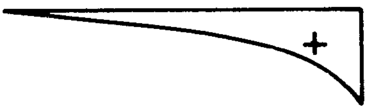
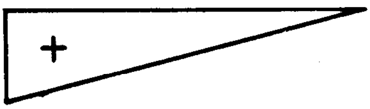
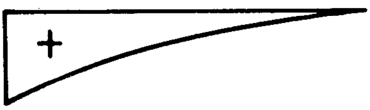
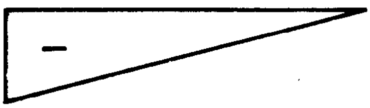
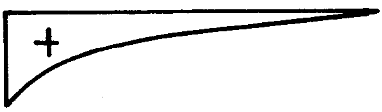
$$= \int \frac{Mm \, dx}{EI}$$



MOMENT DIAGRAM
(DUE TO UNIT LOAD)

This integral can be obtained by multiplying the area of M diagram of each member by the ordinate of m diagram in the same member corressponding to the centre of gravity of M diagram. This calculation is shown in Table 91.

TABLE 91 DEFLECTION CALCULATION

MEMBER	MOMENT DIAGRAM	ORDINATE OF m DIAGRAM CORRESPONDING C G OF M DIAGRAM	AREA OF M DIAGRAM	∫ MMDX
(1)	(2)	(3)	(4)	(5) = (3) × (4)
AB	 6954	0	+ 20862	0
	 2430	0	− 4860	0
BC	 4524	− 1.5	+ 42918	− 64378
	 6342	− 2.0	− 30083	60166
	 2635	− 2.25	+ 8333	− 18749
CD	 4002	− 4.5	− 37966	170847
1149		− 4.0	+ 5450	− 21800
3645		− 3.75	+ 11527	− 43226
DE 9672		− 4.0	+29016	116064
5670		− 4.5	+ 11340	− 51030
				147893

Let deflection = Δ

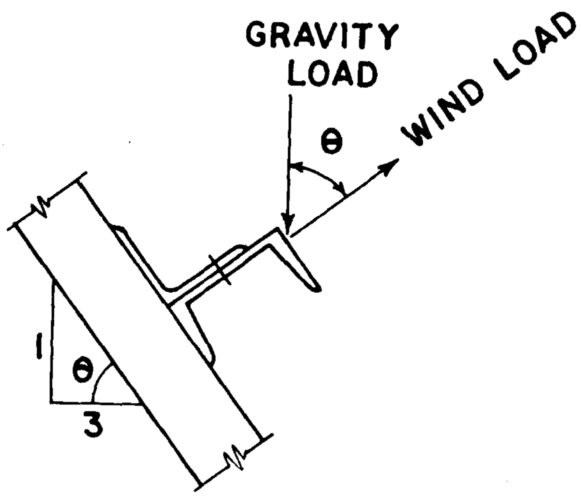
$$\Delta I = \int \frac{Mm\,dx}{E} = \frac{147\,893 \times 10^6}{2.047 \times 10^6} = 0.72 \times 10^5$$

The corresponding value given in Table 34 $= 0.72 \times 10^5$

6.2 Purlin Design

Purlin is designed with one sag rod at mid span.

Maximum spacing of purlin	= 1.4 m
Weight of sheeting	= 1.4 × 17 = 23.80 kg/m
Self-weight of purlin (say)	= 18.00 kg/m
Total dead load (*DL*)	= 41.8 kg/m
Total live load (*LL*)	= 58.13 × 1.4 = 81.38 kg/m
DL + *LL*	= 123.18 kg/m
Wind load uplift force	= 0.8 × 100 × 1.4 = 112 kg/m
Net uplift force	= 112 − 41.8 × cos (18.435)° = 72.3 kg/m



Considering the unsymmetrical/bending of the channel section,

$$M_{xx} = \frac{123.18 \times \cos 18.435 \times 6 \times 6}{8} = 525.9 \text{ kg.m}$$

Considering the sag rod at mid span,

$$M_{yy} = \frac{123.18 \times \sin 18.435 \times 3 \times 3}{8} = 43.8 \text{ kg.m}$$

checking the section ISMC 125

$$f_{bc} = \frac{52\,590}{66.6} + \frac{4\,380}{13.1}$$
$$\doteq 1\,124.0 < 1\,650 \text{ kg/cm}^2$$

Under uplift condition,

$$M_{xx} = \frac{72.3 \times 36}{8} = 325.4 \text{ kg.m}$$

$$M_{yy} = \frac{41.8 \times \sin 18.435 \times 9}{8} = 14.9 \text{ kg.m}$$

$$f_{bc} = \frac{32\,540}{66.6} + \frac{1\,490}{13.1}$$
$$\doteq 603 < 1.33 \times 1\,650 \text{ kg/cm}^2$$

Therefore, it is OK.

Size of Sag Rod

Assume the size	= ISRO 12 mm dia
Number of purlin	= 8

Total load on sag rod

$$= \frac{5 \times 123.18 \times \sin 18.435 \times 6 \times 8}{8} = 1\,168 \text{ kg}$$

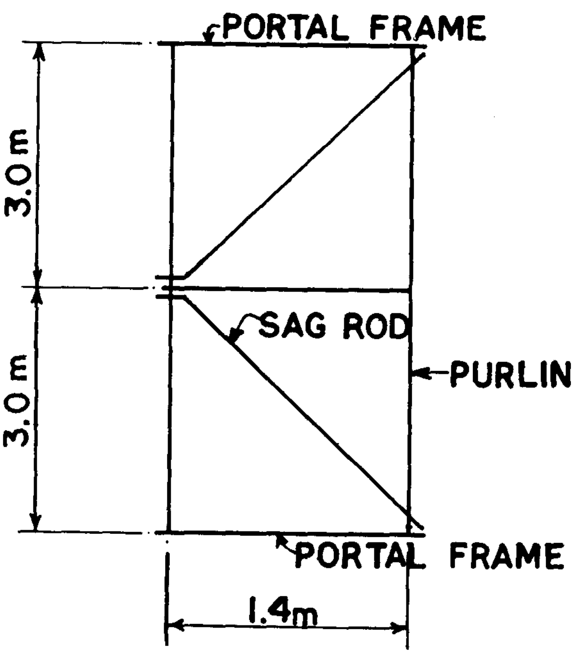
Required net area of sag rod

$$= \frac{1\,168}{1\,500} = 0.78 \text{ cm}^2$$

Use 12 ϕ rod.

Size of Diagonal Sag Rod

Diagonal sag rods are used atleast every eighth panel of purlin from bottom and at the topmost panel of purlins.



Maximum force in the sag rod

$$= \frac{5}{8} \times 123.18 \times \sin 18.435 \times 6 \times 8 = 1169 \text{ kg}$$

Maximum force in diagonal sag rod

$$= \frac{1\,169\sqrt{1.4^2 + 3^2}}{2 \times 1.4} = 1\,382 \text{ kg}$$

Required net area of diagonal

$$\text{sag rods} = \frac{1\,382}{1\,500} = 0.92 \text{ cm}^2$$

Use 12 ϕ rods.

Tube Purline (IS : 806-1968) Y_{st} 25 grade

Minimum out side dia of pipe $= \frac{l}{40} = \frac{6\,000}{40}$
$= 150$ mm

Section modulus required $= \frac{123.18 \times 6 \times 600}{13\,230}$
$= 33.5$ cm^3

Use 150 light tubes for purlins

Girt Design

Span of girt

For vertical bending $= 3.0$ m

For horizontal bending $= 6.0$ m

Maximum spacing of girt $= 1.7$ m

Channel Girt with Sag Rod at the Centre

Vertical bending

AC sheet weight $= 17 \times 1.7 = 28.9$ kg/m

Girt self-weight (say) $= 15.0$ kg/m

Total *DL* $= 43.9$ kg/m

Vertical BM $= M_{yy} = 49.4$ kg/m

$= \frac{43.9 \times 3^2}{8}$

Horizontal bending

Wind load
$= 0.7 \times 0.75 \times 100 \times 1.7 = 89.3$ kg. m

Horizontal BM
$= \frac{89.3 \times 6^2}{8} = 401.9$ kg. m

Try ISMC 125 at 12.7 kg/m

$$f_{bc} = \left(\frac{49.4}{13.1} + \frac{401.9}{66.6}\right) = 100$$
$$= 980 \text{ kg/cm}^2 < 1\,650 \text{ kg/cm}^2$$

(No increase in permissible stress is taken since wind load causes predominent stress)

Tension in central straight sag rod/purlin
$= \frac{5}{8} \times 43.9 \times 6$
$= 164.6$ kg

Maximum number of panels supported
$= \frac{6.0}{1.7} = 4$ (say)

Maximum tension in straight sag rod $= 4 \times 164.6$
$= 658$ kg

Required net area of sag rod $= \frac{658}{1\,500}$
$= 0.44$ cm^2

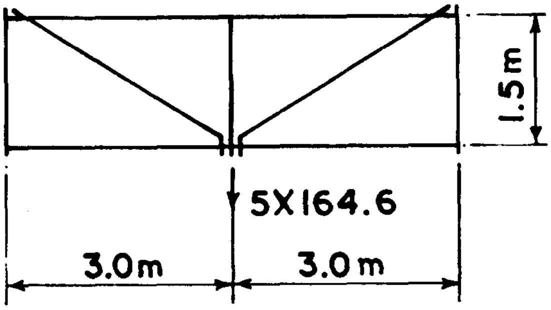
Use 12 ϕ rods.

Number of girts supported by diagonal sag rods $= 5$

(including eaves purlin)

Actual spacing of girts $= 6.0/4 = 1.5$ m

Tension in diagonal sag rod



$$= \left(\frac{164.6 \times 5}{2. \times 1.5}\right) \times \sqrt{3^2 \times 1.5^2}$$
$= 920$ kg.

Net area of rod required

$$= \frac{920}{1\,500} = 0.61 \text{ cm}^2$$

Use 12 ϕ rod.

Using Tubular Girt

Vertical BM $= \frac{43.9 \times 6^2}{8} = 198$ kg. m

Horizontal BM $= \frac{89.3 \times 6^2}{8} = 401.9$ kg. m

Resultant BM $= \sqrt{198^2 + 401.9^2} = 448$ kg. m

Try 100 L-tube

$$f_b = \frac{448 \times 100}{34.0}$$
$= 1\,317$ kg/cm$^2 < 1\,655$

Therfore, it is OK

Use 100 *L*-tube.

NOTE — Restriction of slenderness ratio applicable for tubular purlins need not be applied for girts.

6.3 Frame Members Design

Column forces as given in Table 34 are

Axial force $= 4\,442$ kg

Moment $= 965\,300$ kg. cm

Maximum sway deflection $\times I$ $= 0.774 \times 10^5$ cm^4

Try ISMB 500/86.9

$(l/r)_{xx} = \dfrac{3.0 \times 600}{20.21} = 89.06$

$(l/r)_{yy} = \dfrac{0.75 \times 600}{3.52} = 127.84$

Allowable compressive stress

$= 597 + (671 - 597)\left(\dfrac{130 - 127.84}{10}\right)$

$= 613$ kg/cm^2

Effective length for lateral buckling (l) $= 600 \times 1 = 600$ cm

Torsional constant (K) $= 82.5$ cm^4

Effective depth (h) $= 50 - 1.72 = 48.28$ cm

Critical buckling stress

$$= C_s = 1.2 \times 10.1 \times 10^6 \times \frac{I'_y h}{Z_n \times l^2}\left[1 + 0.162\frac{Kl^2}{I'_y h^2}\right]$$

where

I'_y = modified moment of inertia about yy-axis $= 1.0 \times 1\,369.8 = 1\,369.8$ cm^4

Z_n = section modules about xx-axis $= 1\,808.7$ cm$_3$

and l, k, h are indicated above.

$$C_s = \frac{1.2 \times 10.1 \times 10^6 \times 1\,369.8 \times 48.28}{1\,808.7 \times 600^2}\sqrt{1 + \frac{0.162 \times 82.5 \times 600^2}{1\,369.8 \times 48.28^2}}$$

$= 1\,949$ kg/cm^2

$$f_{bc} = 992 + (1087 - 992)\frac{149}{200} = 1\,063 \text{ kg/cm}^2$$

Checking the column for simultaneous action of axial compression and moment

$$\frac{f_c}{P_c} + \frac{f_{bc}}{P_{bc}} < 1.0$$

where

f_c = calculated axial compressive stress,

f_{bc} = calculated bending compressive stress in extreme-fibre,

P_c = permissible compressive stress, and

P_{bc} = permissible bending compressive stress on extreme-fibre

$$\frac{4\,442}{110.74 \times 613} + \frac{965\,300}{1\,808.7 \times 1\,063} = 0.567 < 1.0$$

Therefore, it is OK.

Checking for deflection

From Table 34, $\Delta\ I = 0.744 \times 10^5$ cm^5

Deflection for ISMB 500,

$$\Delta = \frac{0.744 \times 10^5}{I_{ISMB\ 500}} = \frac{0.744 \times 10^5}{45\,218.3} = 1.65 \text{ cm}$$

Allowable deflection

$$= \frac{600}{325} = 1.84 \text{ cm} > 1.65$$

Therefore, it is OK.

Beam Design

Try ISMB 500/86.9

Design moment $= 965\,300$ kg. cm

Corresponding axial force $= 2\,790$ kg

Inclined length $= 9.49$ m

$(l/r)_{xx} = \dfrac{0.75 \times 949}{20.21} = 35.2$

$(l/r)_{yy} = \dfrac{0.75 \times 949}{3.52} = 202.2$

Allowable compressive stress

$= 243 + (270 - 243)\dfrac{(210 - 202.2)}{10}$

$= 264.1$ kg/cm^2

$(l/r)_{yy} = \dfrac{140}{3.52} = 39.77$

$$C_s = \frac{1.2 \times 10.1 \times 10^6 \times 1\,369.8 \times 48.28}{1\,808.7 \times (140^2)}\sqrt{1 + \frac{0.162 \times 82.5 \times (140)^2}{1\,369.8 \times (48.28)^2}}$$

$= 23\,519.407$

$f_{bc} = 1\,650$ kg/cm^2

Checking for simultaneous section of axial force and moment

$$= \frac{2\,790}{110.74 \times 264.1} + \frac{965\,300}{1\,808.7 \times 1\,650} = 0.42 < 1$$

Therefore, it is OK.

Sections are conservative from strength point of view since deflection governs the design.

6.4 Column Base Plate for Hinged Type of Support

Column Size ISMB 500/86.9

Try 550 × 300 × 18 cm plate (as given in Table 89)

In this example, the force on foundation as given in Table 80 are:

Dead load (DL) = 2 339 kg downward

Live load (LL) = 2 618 kg downward

Wind load (WL) for 100 kg/m^2 } $= \frac{-4\,860}{2}$ = 2 430 kg upward

$DL + LL$ = 2 339 + 2 618 = 4 957kg

0.75 ($DL + WL$) = 0.75(2 430 − 2 339) = 68 kg upward

Since the live load intensity in Table 80 is governed by 1 in 5 slope, the total downward force in Table 80 is slightly larger than the value obtained from analysis.

As the $DL + WL$ forces are not governing the design, design the base plate for $DL + LL$ forces.

Add forces due to self-weight of column and side claddings:

Self-weight of column = 87 × 6 = 522 kg

Dead load of AC sheeting and girts = 30 × 6 × 6 = 1 080 kg

Total axial force in column = 6 559 kg

Thickness of base plate (t)

$$= \sqrt{\frac{3W}{P_{bct}} \times (A^2 - B^2/4)}$$

where

W = pressure on the underside of the base plate,

A = greater projection of plate beyond column

$= \frac{30 - 18}{2} = 6$ cm,

B = lesser projection of plate beyond column

$= \frac{55 - 50}{2} = 2.5$ cm,

P_{bct} = permissible bending stress in base plate = 1 890 kg/cm^2

Therefore

$$t = \sqrt{\frac{3 \times 6\,559\,(6^2 - 2.5^2/4)}{50 \times 30 \times 1\,890}}$$

= 0.5 cm < 1.8 cm provided

Therefore, it is OK.

Provide 4 — ϕ 18 bolts for anchorage.

Due to standardization, sizes of the base plate recommended in Table 88 may be conservative for some cases as in the above example. It may be still desirable to provide the larger size from the stiffness considerations. If one desires more economical design for particular case, the above design procedure can be adopted.

Horizontal Shear in Base Plate

From Table 80

Total horizontal shear due to $DL + LL$ = 847 + 994 = 1 841 kg

This is larger than the value from analysis (given in Table 80) due to higher value of live load (1 in 5) for which tabulated values are given.

Bearing area of base key = 30 × 6 = 180 cm^2

Bearing stress on foundation

concrete $= \frac{1\,841}{180} = 10.2$ kg/m^2

Allowable stress (0.25 f_{ck}) = 0.25 × 200 = 50 kg/cm^2

This is OK.

6.5 Design Example of a Fixed Column Base Plate

Taking the same frame given in **6.4** with fixed base column and 200 kg/m^2 wind zone,

Column required from Table 6 = ISMB 400/61.6

Base plate size = 600 × 450 × 40 mm

Forces : From Table 79

Load	*Axial* (kg)		*Shear* (kg)	*M* (kg. m)
	C	*T*		
DL	2 339	0	1 403	3 820
LL	2 618	0	1 665	4 220
WL (200)	0	−5 150	5 337	10 816

Self-weight of column = 62 × 6 = 372 kg.

DL of AC sheeting and girts = 30 × 6 × 6 = 1 080 kg

DL + LL Case

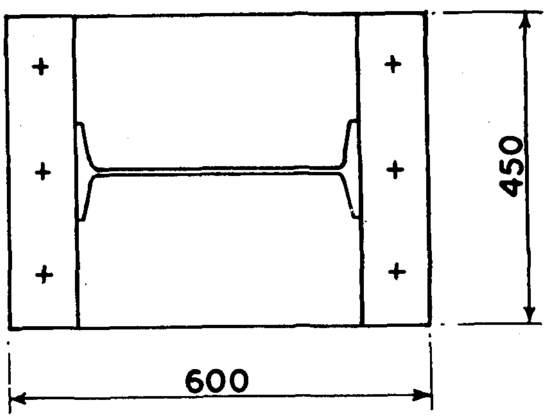
Total axial compression } = 2 339 + 2 618 + 372 + 1 080 = 6 409 kg

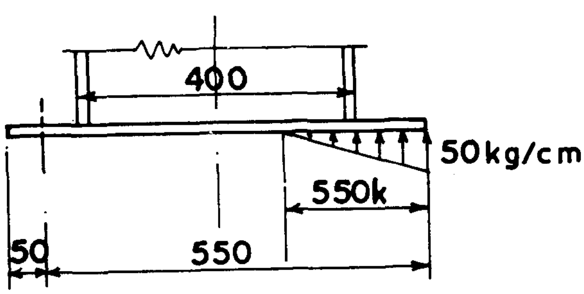
Shear	= 1 403 + 1 665 = 3 063 kg
Bending moment	= 3 820 + 4 220 = 8 040 kg. m

0.75 (DL + WL) Case

Axial tension	= 0.75 (− 2 339 − 372 − 1 080 + 5 150) = 1 020 kg
Shear	= 0.75 (1 403 + 5 337) = 5 055 kg
Bending moment	= 0.75 (10 816 − 3 820) = 5 247 kg. m

DL + LL governs design using M 20 concrete,





Maximum bearing pressure $= 0.25\, f_{ck}$

$= 0.25 \times 200$

$= 50$ kg/cm²

Taking moment about the tension bolt,

$$\frac{1}{2} \times 50 \times k \times 55^2 \times 45 \times \left(1 - \frac{k}{3}\right) - 6\,409 \times (30 - 5)$$

$$k^2 - 3k + 0.85 = 0$$

$$k = 0.317$$

Force in bolts

$$= \frac{1}{2} \times 50 \times (0.317 \times 55)\, 45 - 6\,409 = 13\,205 \text{ kg.}$$

DL + WL case

Taking moment about the tension bolt,

$$\frac{1}{2} \times 50 \times k \times 55^2 \times 45 \times \left(1 - \frac{k}{3}\right) + 1\,020(30 - 5) = 52\,4\,700$$

$$k^2 - 3k + 0.44 = 0$$

$$k = 0.155$$

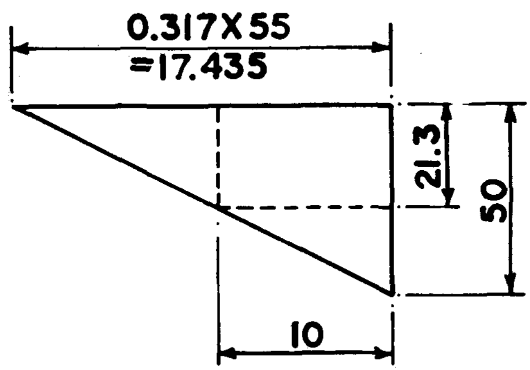
Force in bolts

$$= \frac{1}{2} \times 50 \times (0.155 \times 55) \times 45 + 1\,020$$

$= 10\,611$ kg $<$ *DL + LL* case

Maximum force in bolts = 13 205 kg

Maximum Bending Moment in Base Plate



On tension side = 13 205 (10 − 5) = 66 025 kg.cm

On compression side

$$= 45 \left(\frac{21.3 \times 10^2}{2} + \frac{28.7}{2} \times 10 \times \frac{20}{3}\right)$$

= 90 974.9 kg.cm

Stress in base plate

$$= \frac{90\,974.9 \times 6}{45 \times 4^2} = 758 \text{ kg/cm}^2 < 1\,890 \text{ kg/cm}^2$$

Therefore, it is OK.

Tensil stress in 3 − 36 ϕ bolts

$$= \frac{13\,205 \times 4}{\pi \times 3.6^2 \times 0.75 \times 3}$$

$= 577$ kg/cm² < 945 kg/cm²

Therefore, it is OK.

The base plate and bolt design are conservative in this case, since this is categorized alongwith other typified sections which govern the design.

6.6 Transfer of Forces from Column to Base Plate

m = 804 000 kg.cm

p = 6 409 kg

Maximum force in weld between column and stiffener plate

$$= \left(\frac{80\,4000}{40} + \frac{6\,409}{2}\right)\Big/2 = 11\,652 \text{ kg}$$

Force per unit length of weld $= \dfrac{11\,652}{25} = 466$ kg

Assuming shear stress in fillet weld $= 1\,025$ kg/cm^2

Strength of 1 mm size weld per cm length

$$= \frac{1}{10} \times 0.7 \times 1\,025$$
$$= 71 \text{ kg}$$

Size of weld required

$$= \frac{466}{71}$$
$$= 6.6 \text{ mm} < 8 \text{ mm}$$

Therefore, it is OK.

Forces in weld between stiffener plate and base plate

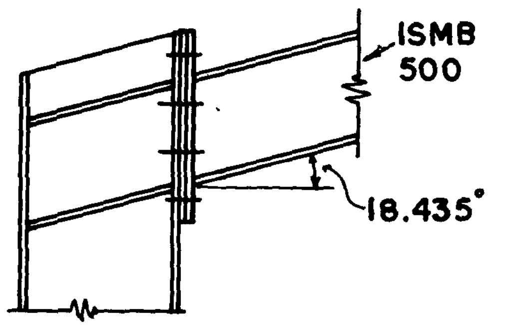
$$= 11\,652 \times 2$$
$$= 23\,304 \text{ kg}$$

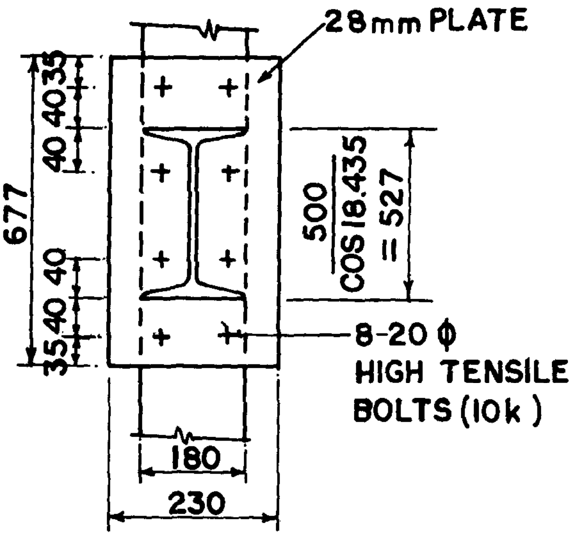
Length of weld $= 2 \times 45 - 14 = 76$ say 70 cm

Size of weld required

$$= \frac{23\,304}{71 \times 70}$$
$$= 4.7 \text{ mm} < 8.0 \text{ mm}$$

Therefore, it is OK.





6.7 Frame Connection For Hinged Base

Haunch Connection — From Table 34

Forces to be transferred

Bending moment (M) $= 9\,653$ kg. m

Shear force $= 4\,442$ kg

Flange force

$$= \frac{9\,653 \times 100}{(50 - 1.72)/\cos 18.435}$$
$$= 18\,968 \text{ kg}$$

Force/bolt (P) $= \dfrac{18\,968}{4} = 4\,742$ kg

Try 20 ϕ/high strength ($10k$) bolts

Prying force (Q) $= \dfrac{P(100b\,\phi^2 - 18\,w\,t^2)}{(70a\,\phi^2 + 21\,w\,t^2)}$

where

P = externally applied force per fastener;

b = distance from fastener line to near face of flange;

ϕ = nominal bolt diameter;

w = length of plate tributary to each belt;

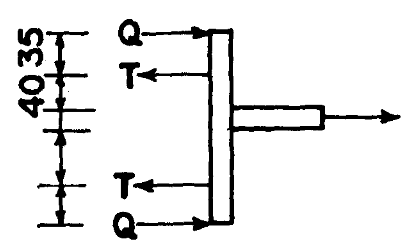
a = distance from fastener line to edge of plate, not to exceed 2 t; and

t = thickness of plate.

NOTE — Prying force is an action that occurs in bolted connections, when loaded in tension causing an additional tensile force in the bolt owing to the tendency of the connection material to pull away (pry) from the column flange.

$$= \frac{4\,742\,(100 \times 40 \times 20^2 - 18 \times 115 \times 28^2)}{(70 \times 35 \times 20^2 + 21 \times 115 \times 28^2)}$$
$$= -37.8 \text{ (– ve value)}$$

$\therefore Q = 0$



Total tension/belt $= f_t = P + Q = 4\,742$ kg

$$\text{Shear/bolt } (f_v) = \frac{4\,442}{8} = 555 \text{ kg}$$

HSFG Connection

Proof load = 20 300 kg
[IS : 1367 (Part 3)-1979]

Allowable shear (IS : 4000 – 1967)
= (Proof load – Tension in bolt × F)

$$\times \frac{\text{Slip factor} \times N}{\text{Factor of safety}}$$

where

N = number of effective interfaces (1);

F = 1.7, if external tension is non-repetitive;

Slip factor = 0.45; and

Factor of safety = 1.4.

Allowable shear

$$= (20\,300 - 4\,742 \times 1.7) \times \frac{0.45}{1.4}$$

$= 3\,934$ kg > 555 kg

Therefore, it is OK.

High Tensile Bolt Connection

(**8.9.4.1** and **8.9.4.3** of IS : 800 – 1984)

Allowable tension (f_t)

$$= 1\,200 \times \frac{\pi}{4} \times 2^2 \times 0.75 \times \frac{10\,000 \times 0.7}{2350}$$

= 8 422 kg

Allowable shear (f_v)

$$= 800 \times \frac{\pi}{4} \times 2^2 \times 0.75 \times \frac{10\,000 \times 0.7}{2\,350}$$

= 5 615 kg.

For combined tensile and shear stress,

$$\left(\frac{f_t}{F_t}\right)^2 + \left(\frac{f_v}{F_v}\right)^2 < 1$$

$$\left(\frac{4\,742}{8\,422}\right)^2 + \left(\frac{555}{5\,615}\right)^2 = 0.33 < 1$$

Therefore, it is OK.

Bending Moment in the End Plate

At bolt line $= Q \times a = 0$

At flange face $= Tb - Q\ (a + b)$
$= 4\,742 \times 4 = 18\,968$ kg.cm

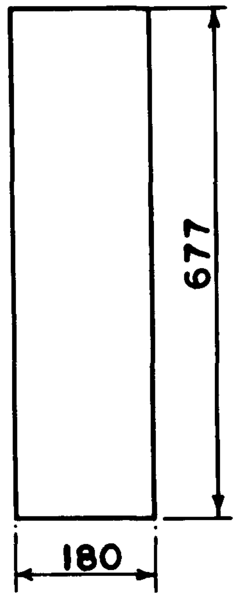
Thickness of end plate required

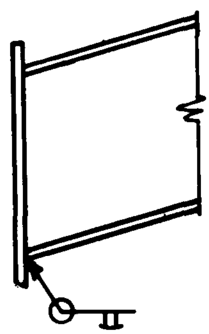
$$= \sqrt{\frac{6 \times 18\,968 \times 2}{1\,575 \times 23}}$$

$= 2.5 < 2.8$ cm

Therefore, it is OK.

Weld Between Column End Plate and Column





Using fillet weld all round,

Total weld length = 2 (67.7 + 18) = 171.4 cm

$$I \text{ of weld} = 2\left[\frac{(67.7)^3}{12} + 18\,\frac{(67.7)^2}{2}\right]$$

$= 92\,964$ cm^4

Force per Unit Length of Weld

$$\text{Vertical} = \frac{4\,442}{171.4} = 25.9 \text{ kg/cm}$$

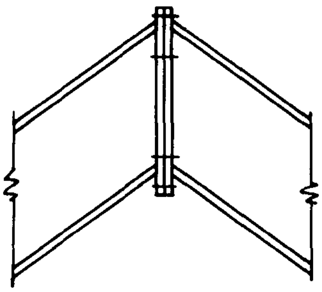
$$\text{Horizontal} = \frac{965\,300 \times 33.85}{92\,964} = 351.5 \text{ kg/cm}$$

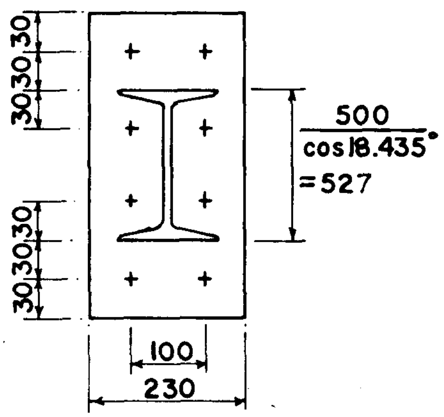
Resultant = 352.5 kg/cm.

Using minimum size of weld = 6.0 mm

Strength of weld/unit length = 6.0 × 71
= 426 kg/cm > 352.5 kg/cm

Use full penetration butt weld between rafter beam and end plate.





Crown Connection

M = 5 376 kg. m (From Table 90)

$V = 0$

$$\text{Flange force} = \frac{5\,376 \times 100\ (\cos 18.435)}{(50 - 1.72)}$$
$$= 10\,564 \text{ kg.}$$

$$\text{Force/bolt} = p = \frac{10\,564}{4} = 2\,641 \text{ kg}$$

Try 16 ϕ high tensile bolts and 16 mm plate

Prying force (Q)

$$= \frac{2\,641\ (100 \times 30 \times 16^2 - 18 \times 115 \times 16^2)}{(70 \times 30 \times 16^2 + 21 \times 115 \times 16^2)}$$
$$= 544 \text{ kg}$$

Total tension in bolt $= P + Q = 2\,641 + 544$
$= 3\,185$ kg

Allowable tension in 16 ϕ (10K bolts)

For HSFG bolt $= 0.6 \times 13\,000$
$= 7\,800 \text{ kg} > 3\,185$ kg

For high tensile bolt

$$= 1200 \times \frac{\pi}{4} \times 1.6^2 \times 0.75 \times \frac{10\,000 \times 0.7}{2\,350}$$
$$= 5\,390 > 3\,185 \text{ kg}$$

Therefore, it is OK

M_{max} in Plate

$Q \times a = 544 \times 3 = 1\,632$ kgcm

$T \times b - Q\ (a + b) = 3\,185 \times 3 - 544 \times 6$
$= 6\,291$ kg. cm

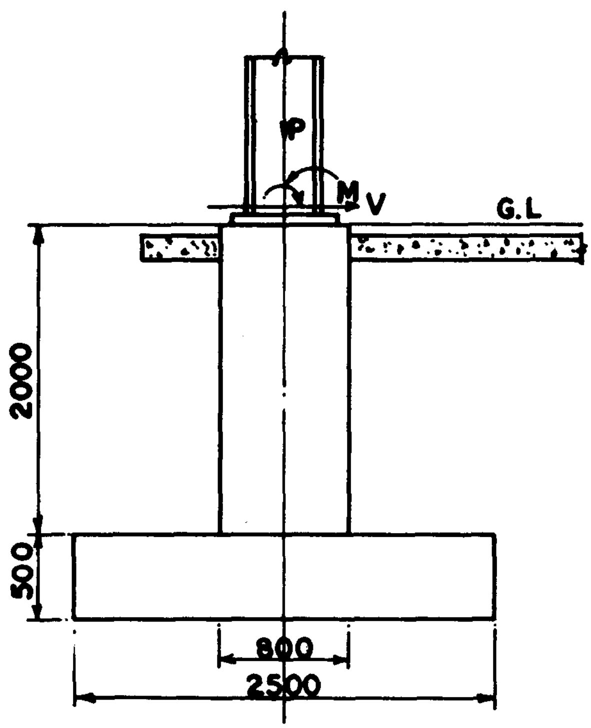
$$t_{reqd} = \sqrt{\frac{6\,291 \times 6 \times 2}{1\,575 \times 23.0}} = 1.44 \text{ cm} < 1.6 \text{ cm}$$

Therefore, it is OK.

Use full penetration butt weld to connect end plates to the rafter beams.

6.8 Design of Foundation

Typified design of foundation is not included in this report since the soil condition which varies from site to site would influence the design of foundation. A typical example of isolated footing design for assumed field condition is illustrated in this section. Limit state design in accordance with IS : 456-1978 is used in this example. The fixed base portal foundation in **6.5** is designed here.



Assumptions

F_{ck} = 20.0 MPa

Allowable bearing pressure on soil = 15 000 kg/m^2

Required depth of footing below grade = 2.5 m

Unit weight of soil back fill = 1 500 kg/m^2

The design is illustrated for $DL + LL$ case and has to be checked for $DL + WL$ case. In this particular case, $DL + WL$ case does not govern the design.

Forces in Foundation

	$DL + LL$	$0.75\ (DL + WL)$
P (kg)	6 409	0
T (kg)	0	1 020
V (kg)	3 068	5 055
M (kgm)	8 040	5 247

Development Length of Anchor Bolts

From the design of base plate (*see* **6.5**):

Total tension in 3 bolts = 13 205 kg

∴ actual tension in one bolt $= \frac{13\,205}{3}$ = 4 402 kg

Net area of 36 mm ϕ bolt (net area taken as 0.75 times gross area) = 7.63 cm^2

Stress in steel in limit state of collapse $= \frac{4\,402 \times 1.5}{7.63}$ = 865 kg/cm^2

Development length required $= \frac{865 \times 36}{10 \times 1.0 \times 4}$ = 78 cm

Use 80 cm embedment in concrete pedestal.

Design of Pedestal

Let size of pedestal = 0.8 × 0.65 m

Self-weight of pedestal = 0.80 × 0.65 × 2 × 2 500 = 2 600 kg

Total downward load = 2 600 + 6 409 = 9 009 kg

Moment at base of pedestal due to shear = 2 × 3 068 = 6 136 kg. m

Total moment at base of pedestal = 6 136 + 8 040 = 14 176 kg. m

∴ Design compression = 1.5 × 9 009 = 13 514 kg

Design moment = 1.5 × 14 176 = 21 264 kg. m

f_{ck} = 20 N/mm^2

$$\frac{M_u}{f_{ck} b D^2} = \frac{21\,264 \times 10^4}{20 \times 650 \times 800^2} = 0.025$$

$$\frac{P_u}{f_{ck} b D} = \frac{13\,514 \times 0}{20 \times 650 \times 800} = 0.013$$

From chart 31 of SP : 16-1980,

For Fe 415 and $\frac{d'}{D} = 0.05$

$\frac{p}{f_{ck}} = 0.018$

p = 0.018 × 20 = 0.36 percent

But minimum reinforcement required in compression member is 0.8 percent

Therefore, area of longitudinal steel

$= \frac{0.8}{100} \times 650 \times 800$ = 4 160 mm^2

Provide 8 bars of 28 mm ϕ, A_t = 4.926 mm^2

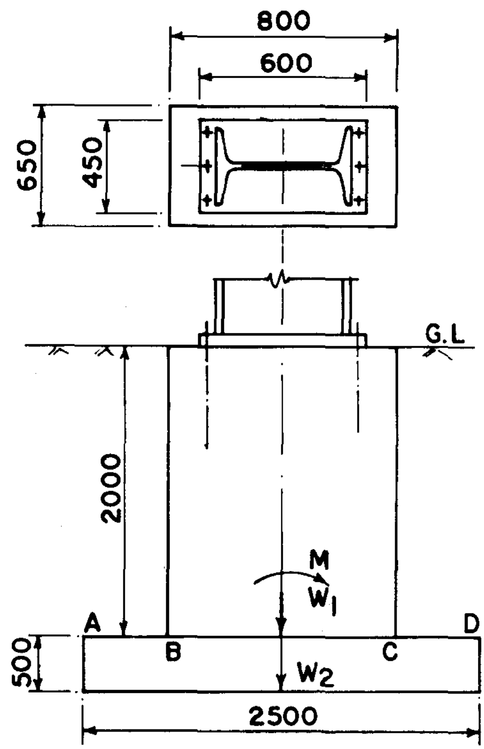
Reinforcement may be distributed equally in all faces since only nominal steel required to resist the actual bending moment.

Lateral Ties

Diameter = greatest of: (a) 5 mm or (b) ¼ diameter of main bar = ¼ × 28 = 7 mm

Therefore, provide 8 mm lateral ties.

Spacing of ties = least of the following:



a) least lateral dimension = 650 mm

b) 16 times diameter of main bar = 16 × 28 = 448 mm

c) 48 times diameter of ties = 48 × 8 = 384 mm

Therefore, provide 8 mm lateral ties at 38 cm c/c.

Design of Footing

Direct load from pedestal (w_1)	= 9 009 kg
Safe bearing capacity of soil	= 15 t/m^2 = 15 000 kg/m^2
Unit weight of soil	= 1 500 kg/m^3

Try a footing 2.0 m × 2.5 m × 0.5 m

Weight of soil above footing (w_3)

$= (2 \times 2.5 - 0.65 \times 0.8) \times 2 \times 1\,500$

$= 13\,440$ kg

Weight of footing (w_2) $= 2 \times 2.5 \times 0.5 \times 2\,500 = 6\,250$ kg

Load from pedestal (w_1) = 9 009 kg

Total vertical load $= w_1 + w_2 + w_3 = 28\,699$ kg

Overturning moment (M) $= 8\,040 + 3\,068 \times 2.5 = 15\,710$ kg.m

Factor of safety against overturning

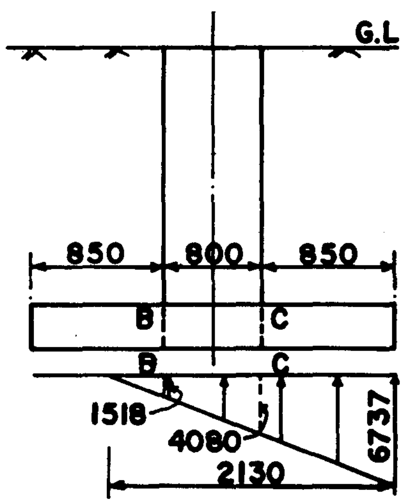
$$= \frac{28\,699 \times 1.2}{15\,710} = 2.2 > 1.5$$

Therefore, it is OK.

Eccentricity of resultant vertical force

$$= \frac{15\,710}{28\,780} = 0.54 \text{ m} > \frac{h}{6} = \frac{2.5}{6}$$

Therefore, base pressure distribution is triangular with part of the footing lifting up.



Width of footing in contact with soil

$$= \left(\frac{b}{2} - e\right) \times 3 = \left(\frac{2.5}{2} - 0.54\right) \times 3$$

$= 2.13$ m

Maximum pressure

$$= \frac{28\,699}{2.0 \times 2.13} = 6\,737 \text{ kg/m}^2 < 15\,000 \text{ kg/m}^2$$

Therefore, it is OK.

$$\text{Pressure at } C = \frac{6\,737}{2.13}(2.13 - 0.85) = 4048 \text{ kg/m}^2$$

$$\text{Pressure at } B = \frac{6\,737}{2.13}(2.13 - 1.65) = 1518 \text{ kg/m}^2$$

Maximum Factored BM

(neglecting weight of soil)

At section C

$$= 1.5 \times \left[(6\,737 - 4\,048) \times \frac{0.85}{2} \times \frac{0.85 \times 2}{3} + 4\,048 \times \frac{0.85}{2}\right]$$

= 3 552 kg.m per m width

= 34.8 kN.m/m width

At section B

$$= 1.5 \times 1\,518 \times \frac{(2.13 - 1.65)^2}{2} \times \frac{1}{3}$$

= 87 kg. m/m width = 0.85kN.m/m width

Effective depth
= 50 − 5 = 45 cm (*refer* Chart 5 or SP : 16-1980)

Minimum tension reinforcement of 0.12 percent is sufficient.

Area of steel

$$= 0.12 \times \frac{100}{100} \times 45 = 5.4 \text{ cm}^2\text{/m width}$$

Use 12 # Fe 415 bars at 200 mm c/c top and bottom both ways.

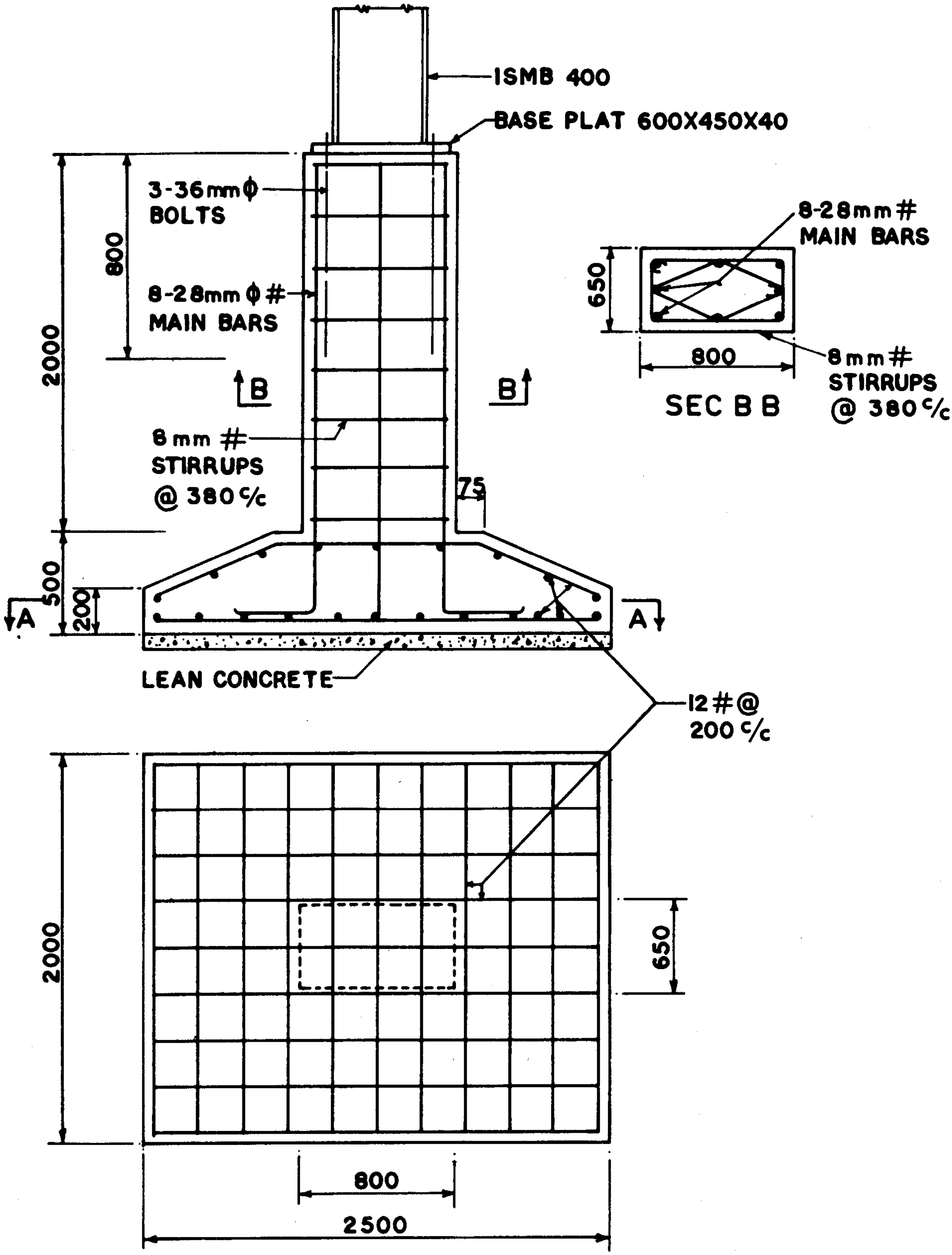
Shear in footing would be small and hence not critical requiring shear reinforcement.

For economy reasons, the depth of footing may be reduced to 200 mm at the free edge as shown in figure below.

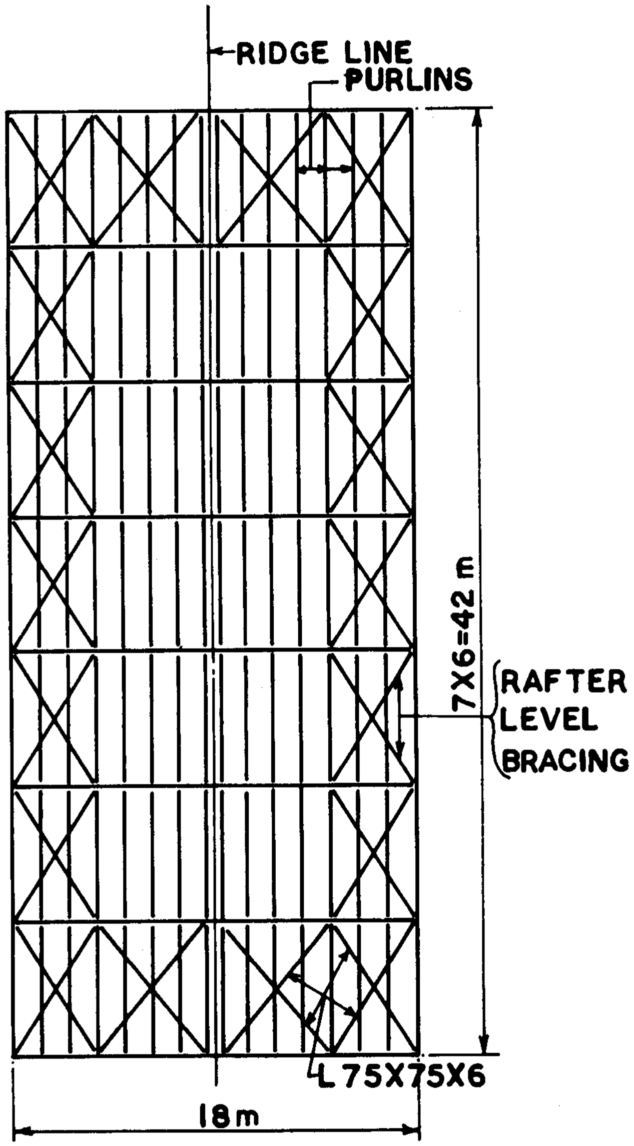
6.9 Bracing Design

Typical bracing arrangements are shown in Fig. 14. Among these, Type *b* bracing for, detail design is illustrated here.

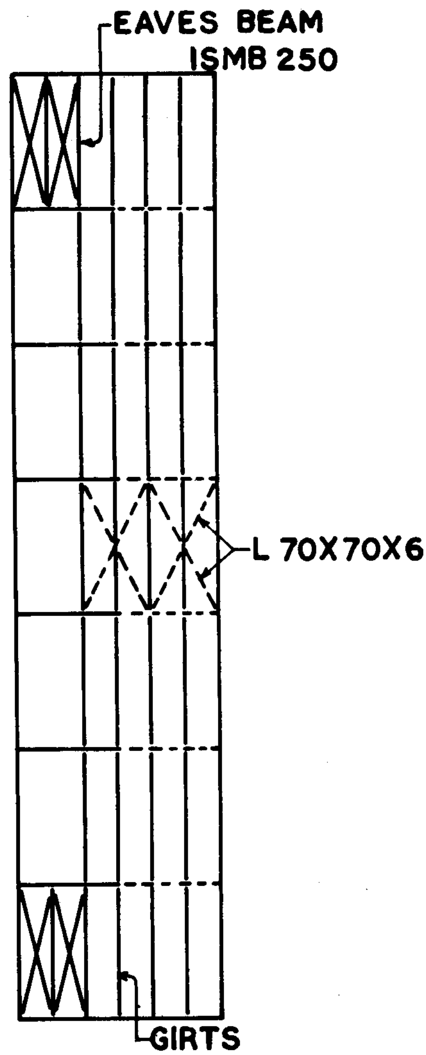
The wind force perpendicular to the ridge is carried by the frame action and hence only nominal bracings are necessary in the gable and


ISMB 400
BASE PLAT 600X450X40
3-36mm ϕ BOLTS
800
8-28mm ϕ # MAIN BARS
2000
B
B
8 mm # STIRRUPS @ 380 c/c
75
500
200
A
A
LEAN CONCRETE
12 # @ 200 c/c
8-28mm # MAIN BARS
650
800
SEC B B
8 mm # STIRRUPS @ 380 c/c
2000
650
800
2500

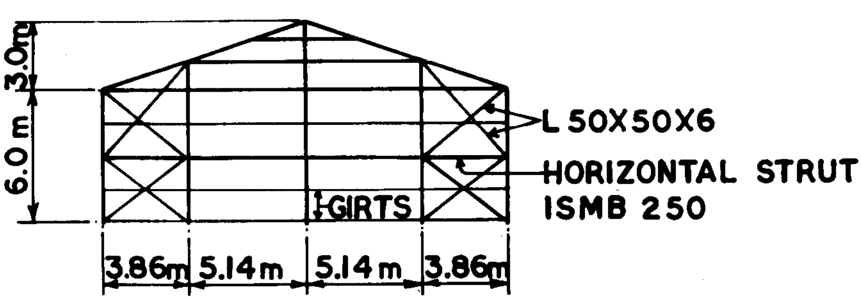
PLAN AT A A



PLAN AT RAFTER LEVEL
(SAG RODS NOT SHOWN)



SIDE ELEVATION



walls, and at rafter level along the length of building.

Gable and Wall Bracings

Maximum length of bracing

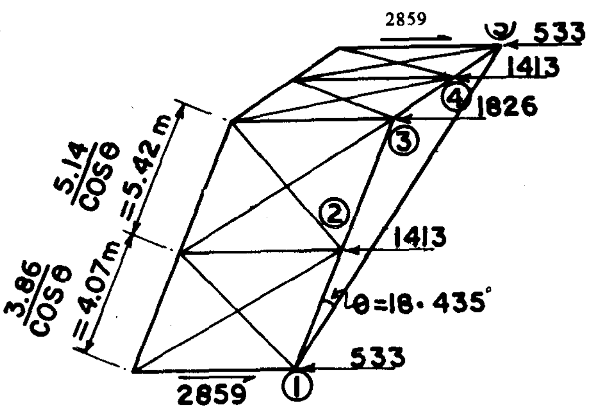
$$= \sqrt{3^2 + \left(3 + \frac{3.86}{3}\right)^2}$$

$$= 5.23 \text{ m} = 523 \text{ cm}$$

V_{min} required $= \frac{523}{350} = 1.5$ cm

Use ISA 5050 × 6

Rafter Level Bracing



Wind pressure on windward gable end $= 0.7 \times 100 = 70$ kg/m^2

Wind drag on roof $= 0.025 \times 100 = 2.5$ kg/m^2

Forces on Windward Gable End Truss

$$\text{At nodes 1,5} = \frac{70 \times 3.86}{2 \times 2}\left(6 + \frac{3.86}{2 \times 3 \times 2}\right) + 2.5 \times \frac{4.07}{2} \times \frac{42}{2} = 533 \text{ kg}$$

$$\text{At nodes 2,4} = 70 \times \frac{(3.86 + 5.14)}{2 \times 2} \times \left(6 + \frac{3 \times 3.86 + 5.14}{2 \times 2 \times 3}\right) + 2.5\left(\frac{4.07 + 5.42}{2}\right) \times \frac{42}{2}$$

$$= 1\,413 \text{ kg}$$

$$\text{At node 3} = 70 \times \frac{5.14}{2}\left(9 - \frac{5.14}{2 \times 3 \times 2}\right) + 2.5 \times 5.42 \times \frac{42}{2} = 1\,826 \text{ kg}$$

The reactions from columns and frames on the rafter bracing truss for equilibrium are shown in the figure.

Maximum bracing force

$$= \frac{(2\,859 - 533) \times \sqrt{6^2 + 4.07^2}}{6}$$

$$= 2\,810 \text{ kg.}$$

Try ISA 75 × 75 × 6

$$l/r_{vv} = \sqrt{\frac{6^2 + 5.42^2}{2 \times 1.46}} \times 100 = 277$$

$$l/r_{xx} = \sqrt{\frac{6^2 + 5.42^2}{2.30}} \times 100$$

$$= 351 \text{ which may be allowed.}$$

Assuming 20 dia bolts,

$$\text{Net effective area} = (4.33 - 2.15 \times 0.6) + \frac{4.33}{(1 + 0.35)\left(\frac{4.33}{4.33 - 2.15 \times 0.6}\right)}$$

$$= 5.93 \text{ cm}^2$$

Allowable tension $= 5.93 \times 1\,500$
$= 8\,895 > 2\,810$ kg

Therefore, it is OK.

Wind pressure on leeward gable end $= 0.3 \times 100 = 30$ kg/m^2

Forces on Leeward Gable End Truss

$$\text{At nodes 1,5} = \frac{30 \times 3.86}{2 \times 2}\left(6 + \frac{3.86}{2 \times 3 \times 2}\right) + \frac{2.5 \times 4.07}{2} \times \frac{42}{2} = 290 \text{ kg}$$

$$\text{At nodes 2,4} = 30 \times \frac{(3.86 + 5.14)}{2 \times 2} \times \left(6 + \frac{3 \times 3.86 + 5.14}{2 \times 2 \times 3}\right) + 2.5\left(\frac{4.07 + 5.42}{2}\right) \times \frac{42}{2}$$

$$= 748 \text{ kg}$$

$$\text{At node 3} = 30 \times \frac{5.14}{2}\left(9 - \frac{5.14}{2 \times 3 \times 2}\right) + 2.5 \times 5.42 \times \frac{42}{2} = 945 \text{ kg}$$

Since the rafter truss is not in one plane, the tipping effect of end gable load has to be resisted by eaves bracing system as shown.

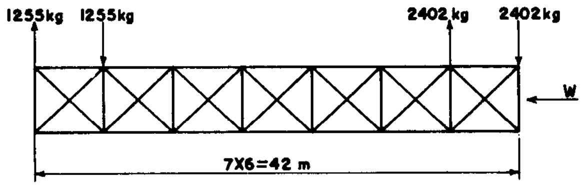
Forces on Eaves Truss due to Tipping Effect

On the windward end

$$= \frac{(1\,413 \times 4.07 + 1\,826 \times 9.49/2)}{6} = 2\,402 \text{ kg}$$

On the leeward end

$$= \frac{(748 \times 4.07 + 945 \times 9.49/2)}{6} = 1\,255 \text{ kg}$$



Eaves truss

Forces due to tipping effect will cause additional stresses on main rafters of portals.

Additional compressive stress in ISMB 500 rafter

$$= \frac{2\,402}{110.74} = 21.7 \text{ kg/cm}^2,$$

which is very small and can be neglected. The length of members of eaves truss is slightly less as compared to the length of members between node 2 and node 3 but for uniformity sake, use ISA $75 \times 75 \times 6$ as designed earlier.

Wind Perpendicular to End Gable

Wind columns in gable ends

Wind pressure on end gable $= 0.7\ P$

$= 0.7 \times 100 = 70 \text{ kg/m}^2$

Height of central column $= 6.0 + 3.0 = 9.0$ m

Maximum moment in the wind columns

$$= \frac{70 \times 5.14 \times 9^2}{8}$$

Try ISWB 450 $= 3\,643$ kgm

$$\frac{l}{r_{yy}} = \frac{900}{3.0} = 300$$

Therefore, it is OK.

Critical stress (C_s)

$$= \frac{1.2 \times 10.1 \times 10^6 \times I_Y h}{2 \times l^2} \sqrt{1 + 0.162 \frac{K l^2}{I_y h^2}}$$

$$= \frac{1.2 \times 10.1 \times 10^6 \times 834\ (45 - 1.74)}{1\,350.7 \times 900^2}$$

$$\sqrt{1 + 0.162 \frac{64.14 \times 900^2}{834\,(45 - 1.74)^2}} = 1\,011$$

Allowable bending compression (F_{bc})

$= 547 \times 1.33 = 727 \text{ kg/cm}^2$

$$f_{bc} = \frac{3643 \times 100}{1\,350.7} = 270 \text{ kg/cm}^2 < 727$$

Therefore, it is OK.

Use ISMB 450 for wind column in gable ends.

Vertical Bracing on Longitudinal Wall

Wind force from windward side

From end gable $= \frac{18}{2} \times \left(\frac{6+9}{2}\right) \times 0.7 \times 100 \times \frac{1}{2}$
$= 2\,363$ kg

From roof drag $= 2.5 \times 9.49 \times 21$
$= 498$ kg

Wall drag at eaves $= 2.5 \times 1.5 \times 21$
$= 79$ kg

Wall drag at mid-column $= 2.5 \times 3 \times 21$
$= 158$ kg

Total force at top of column on windward side
$= 2\,363 + 498 + 79 = 2\,940$ kg

Wind Force From Leeward Side

From end gable $= \frac{18}{2} \times \left(\frac{6+9}{2}\right) \times 0.3 \times 100 \times \frac{1}{2}$
$= 1\,013$ kg

Roof drag $= 498$ kg

Wall drag at eaves $= 79$ kg

Wall drag at mid-column $= 158$ kg

Total force at top of column on leeward side
$= 1\,013 + 498 + 79 = 1\,590$ kg

Try ISMB 250

$$\left(\frac{l}{r}\right)_{yy} = \frac{600}{2.65} = 226 < 250$$

Therefore, it is OK.

Allowable compression $= 207 \times 47.55$
$= 9\,843$ kg $< 2\,940$ kg

Therefore, it is OK.

Length of bracing $= \sqrt{3^2 + 6^2} = 6.7$ m $= 670$ cm

Maximum bracing force

$$= (2\,940 + 1\,590 + 2 \times 158) \times \frac{6.7}{6} = 5\,411 \text{ kg}$$

Try ISA $70 \times 70 \times 6$

$$\left(\frac{l}{r}\right) = \frac{670}{2.14} = 313 < 350$$

Therefore, it is OK.

TABLE 92 UNIT WEIGHT OF PORTAL FRAMES (kg/m²)*

Wind Pressure = 100 kg/m²

SPAN	TYPE OF SUPPORT	NO. OF BAYS	COLUMN HEIGHT	SPACING = 4.5 m Roof Slope			SPACING = 6.0 m Roof Slope		
(m)			(m)	1 in 3	1 in 4	1 in 5	1 in 3	1 in 4	1 in 5
9.0	Fixed	1	4.5	21.80	21.69	21.62	24.77	24.67	24.61
			6.0	29.99	29.02	26.54	28.93	28.79	28.74
		2	4.5	20.38	20.27	20.21	23.47	23.37	23.32
			6.0	24.44	24.30	24.23	26.87	26.74	26.67
		3	4.5	19.92	19.80	19.74	23.04	22.94	22.88
			6.0	23.67	23.53	23.46	26.17	26.05	25.98
		4	4.5	19.68	19.57	19.49	22.82	22.72	22.66
			6.0	23.28	23.15	23.07	25.82	25.70	25.63
	Hinged	1	4.5	34.13	30.16	30.08	32.04	31.85	31.77
			6.0	42.89	42.59	42.46	42.94	42.64	42.54
		2	4.5	27.94	27.72	27.63	29.86	27.23	27.17
			6.0	34.13	33.87	33.77	35.19	34.96	34.87
		3	4.5	27.11	26.90	24.22	26.78	26.62	26.55
			6.0	32.84	32.58	32.47	34.05	30.88	30.80
		4	4.5	26.71	26.49	23.87	26.47	26.31	26.24
			6.0	32.19	31.93	31.83	30.59	30.39	30.31
12.0	Fixed	1	4.5	21.70	21.53	21.46	23.92	23.76	23.69
			6.0	26.22	26.03	25.94	27.82	27.65	27.56
			9.0	44.17	43.77	41.07	43.52	38.66	38.55
		2	4.5	20.41	20.25	20.17	22.75	22.92	22.53
			6.0	24.16	23.97	23.88	25.99	25.82	25.74
			9.0	34.58	34.31	34.18	35.07	34.83	34.72
		3	4.5	22.08	19.81	21.80	22.36	22.21	22.15
			6.0	23.46	23.27	23.18	25.38	25.20	25.12
			9.0	33.11	32.85	32.72	33.79	30.43	33.43
		4	4.5	21.82	21.63	21.54	23.92	23.74	23.66
			6.0	23.12	22.93	22.84	25.07	24.89	24.82
			9.0	32.39	32.12	32.00	33.14	32.90	32.79
	Hinged	1	4.5	30.20	29.93	29.81	31.21	28.24	28.15
			6.0	42.24	36.99	36.85	37.48	37.19	37.07
			9.0	78.76	78.13	77.85	—	—	—
		2	4.5	28.01	24.84	24.74	26.81	26.61	26.52
			6.0	33.88	33.57	33.43	34.46	30.97	30.87
			9.0	59.40	58.86	58.63	57.20	56.73	56.53
		3	4.5	27.28	24.22	24.13	26.26	26.06	25.97
			6.0	32.74	28.96	28.84	30.35	30.12	30.01
			9.0	48.85	48.40	48.21	48.18	47.78	47.48
		4	4.5	26.92	23.92	23.82	25.99	25.79	25.70
			6.0	32.17	28.47	28.35	29.93	29.69	29.59
			9.0	47.64	47.19	47.00	47.10	46.70	46.53
18.0	Fixed	1	6.0	28.19	31.89	31.26	28.94	31.76	31.80
			9.0	41.21	40.84	47.17	41.02	40.69	40.54
			12.0	63.17	62.64	62.39	52.54	52.14	51.95
		2	6.0	33.18	29.13	20.98	30.04	29.75	29.63
			9.0	37.20	36.82	36.65	37.41	37.07	36.92
			12.0	55.51	54.99	54.73	46.78	46.40	46.20
		3	6.0	28.69	28.37	28.22	29.36	29.08	28.96
			9.0	35.86	35.48	40.74	36.20	35.87	35.71
			12.0	52.95	52.41	52.16	44.86	44.46	44.28

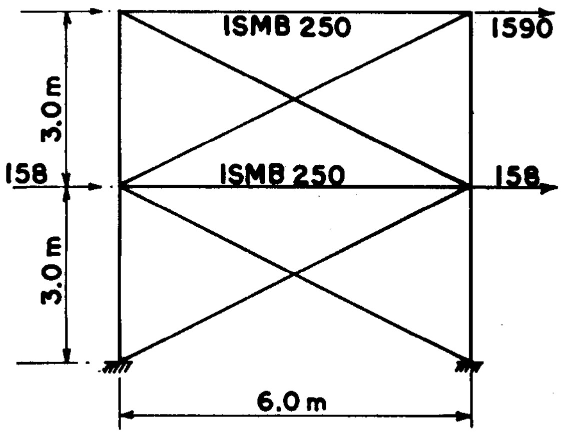
(Continued)

TABLE 92 UNIT WEIGHT OF PORTAL FRAMES (kg/m²)*—Contd.

Wind Pressure = 100 kg/m²

SPAN	TYPE OF SUPPORT	NO. OF BAYS	COLUMN HEIGHT	SPACING = 4.5 m, Roof Slope			SPACING = 6.0 m, Roof Slope		
(m)			(m)	1 in 3	1 in 4	1 in 5	1 in 3	1 in 4	1 in 5
	Hinged	1	6.0	35.88	35.49	35.31	36.23	35.88	35.72
			9.0	—	63.51	63.21	—	—	—
			12.0	—	—	—	—	—	—
		2	6.0	33.20	32.81	28.98	33.82	29.76	29.63
			9.0	57.37	49.22	48.97	—	47.68	47.45
			12.0	—	—	—	—	—	—
		3	6.0	32.31	31.92	31.74	33.01	32.66	32.49
			9.0	47.86	47.30	46.82	46.48	45.98	45.75
			12.0	—	—	—	—	—	—
24.0	Fixed	1	9.0	42.49	48.70	48.45	41.76	46.95	46.75
			12.0	63.61	62.99	62.69	52.54	—	
		2	9.0	38.88	44.38	44.13	38.52	43.14	42.92
			12.0	49.23	56.18	55.89	47.44	—	—
	Hinged	1	9.0	—	—	—	—	—	—
			12.0	—	—	—	—	—	—
		2	9.0	—	51.08	50.78	—	—	—
			12.0	—	—	—	—	—	—
30.0	Fixed	1	9.0	—	—	—	—	—	—
			12.0	—	—	—	—	—	—
	Hinged	1	9.0	—	—	—	—	—	—
			12.0	—	—	—	—	—	—

*Unit weight includes weight of structural steel in the frame and purlins only. It does include the weight of sag rods, base plates, girts, etc.



Assuming 20 Dia Bolts

$$\text{Net effective area} = (4.03 - 2.15 \times 0.6) + \frac{4.03}{\left(1 + \dfrac{0.35 \times 4.03}{4.03 - 2.15 \times 0.6}\right)} = 5.4 \text{ cm}^2$$

$$\text{Allowable tension} = 5.4 \times 1\,500 = 8\,100 \text{ kg} < 5\,411 \text{ kg}$$

Therefore, it is OK.

Additional axial force in column

$$= 5\,411 \times \frac{3}{6.7} = 2\,423 \text{ kg}$$

The column and foundation in the braced bay have to be checked for this additional force.

7. SUMMARY AND CONCLUSIONS

7.1 The analysis and design results of portal frames (without cranes) have been presented for five different spans, two different spacings, three different slopes, two/three different column heights, three different basic wind pressures and five different earthquake zones. It has been found that forces in members, even due to the lowest basic wind pressure of 100 kg/m², is more than that due to the most severe earthquake zone forces.

Comparison of steel portal frames weight per unit plan area (unit weight) has been given in Tables 92 and 94 on the basis of ISMB sections only. These weights include the weight of frame members and purlins. The following conclusions may be drawn from the analysis and design tables, and unit weight tables:

a) It is found that in most of the frames the transverse horizontal deflection limit (1/325) seems to govern the design of members and

TABLE 93 UNIT WEIGHT OF PORTAL FRAMES (kg/m²)*

Wind Pressure = 100 kg/m²

SPAN	TYPE OF SUPPORT	NO. OF BAYS	COLUMN HEIGHT	SPACING = 4.5 m			SPACING = 6.0 m		
				Roof Slope			Roof Slope		
(m)			(m)	1 in 3	1 in 4	1 in 5	1 in 3	1 in 4	1 in 5
9.0	Fixed	1	4.5	24.44	24.30	24.23	26.86	24.67	24.61
			6.0	34.38	33.45	29.73	31.67	31.52	31.44
		2	4.5	22.70	20.27	20.21	23.47	23.37	23.32
			6.0	27.23	27.05	26.97	29.22	29.07	26.67
		3	4.5	22.13	19.80	19.74	23.09	22.94	22.88
			6.0	26.30	26.13	23.46	28.40	26.04	25.98
		4	4.5	21.84	19.57	19.49	24.53	22.72	22.66
			6.0	25.84	23.15	23.07	27.99	25.70	25.63
	Hinged	1	4.5	34.13	33.87	33.77	35.19	34.96	34.87
			6.0	48.62	48.26	48.12	48.67	48.36	48.22
		2	4.5	31.22	30.96	27.63	29.86	29.67	29.59
			6.0	38.32	38.02	37.90	39.00	38.62	38.51
		3	4.5	27.11	26.90	26.81	29.13	28.94	28.86
			6.0	36.81	36.50	36.38	37.55	33.82	33.73
		4	4.5	26.71	26.49	26.40	28.76	28.57	28.49
			6.0	36.05	31.93	31.83	33.48	33.25	33.16
12.0	Fixed	1	4.5	21.70	21.53	21.46	23.92	23.76	23.69
			6.0	30.08	29.15	29.03	27.82	27.65	27.56
			9.0	50.29	49.91	46.55	49.68	49.34	43.09
		2	4.5	22.61	20.25	20.17	22.75	22.92	22.53
			6.0	26.92	24.13	23.88	25.99	25.82	25.74
			9.0	39.03	38.72	38.57	38.99	38.71	38.58
		3	4.5	22.08	19.81	21.80	24.14	22.21	22.15
			6.0	26.10	23.27	23.18	25.38	25.20	25.12
			9.0	37.32	37.00	32.72	37.48	33.55	33.43
		4	4.5	21.82	21.63	21.54	23.92	23.74	23.66
			6.0	25.69	25.47	22.84	25.07	24.89	24.82
			9.0	36.46	32.12	32.00	33.14	32.90	32.79
	Hinged	1	4.5	33.88	29.93	29.80	34.46	30.97	30.87
			6.0	48.85	41.86	41.70	42.44	42.10	41.96
			9.0	—	—	—	—	—	—
		2	4.5	28.01	27.74	27.63	29.29	29.05	28.94
			6.0	38.21	37.83	37.43	38.82	34.18	34.06
			9.0	68.55	67.90	67.64	—	—	—
		3	4.5	27.28	27.01	27.00	28.64	28.41	25.97
			6.0	32.74	32.42	32.29	33.45	33.17	33.05
			9.0	65.14	56.00	55.75	54.65	54.18	53.97
		4	4.5	26.92	26.65	26.53	28.33	28.08	25.70
			6.0	32.17	31.85	31.72	32.95	32.67	32.55
			9.0	55.08	54.54	54.31	53.34	52.90	52.70
18.0	Fixed	1	6.0	28.19	31.39	31.26	28.94	31.76	31.64
			9.0	41.21	40.84	47.17	41.02	40.69	40.54
			12.0	63.17	62.64	62.39	60.06	59.58	59.37
		2	6.0	33.18	29.13	28.98	30.04	29.75	29.63
			9.0	37.20	36.82	36.65	37.41	37.07	36.92
			12.0	55.51	54.99	54.73	46.78	46.40	46.20
		3	6.0	28.69	28.37	28.22	29.36	29.08	28.96
			9.0	35.86	35.48	40.74	36.20	35.87	35.71
			12.0	52.95	52.41	52.16	44.86	44.46	44.28
	Hinged	1	6.0	41.43	40.96	40.75	41.05	40.66	40.43
			9.0	—	—	—	—	—	—
			12.0	—	—	—	—	—	—

(*Continued*)

TABLE 93 UNIT WEIGHT OF PORTAL FRAMES (kg/m²)*—Contd.

Wind Pressure = 150 kg/m²

Span	Type of Support	No. of Bays	Column Height	Spacing = 4.5 m, Roof Slope			Spacing = 6.0 m, Roof Slope		
(m)			(m)	1 in 3	1 in 4	1 in 5	1 in 3	1 in 4	1 in 5
		2	6.0	38.22	32.81	32.63	38.17	33.46	33.30
			9.0	—	—	56.40	—	—	—
			12.0	—	—	—	—	—	—
		3	6.0	37.14	35.85	31.74	37.21	32.66	32.49
			9.0	55.10	54.43	54.13	—	—	—
			12.0	—	—	—	—	—	—
24.0	Fixed	1	9.0	42.49	48.70	48.45	41.76	46.95	46.75
			12.0	63.61	62.99	62.69	—	—	—
		2	9.0	38.88	44.38	44.13	38.52	43.14	42.92
			12.0	49.23	56.18	55.89	47.44	—	—
	Hinged	1	9.0	—	—	—	—	—	—
			12.0	—	—	—	—	—	—
		2	9.0	—	—	—	—	—	—
			12.0	—	—	—	—	—	—
30.0	Fixed	1	9.0	—	—	—	—	—	—
			12.0	—	—	—	—	—	—
	Hinged	1	9.0	—	—	—	—	—	—
			12.0	—	—	—	—	—	—

*Unit weight includes weight of structural steel in the frame and purlins only. It does include the weight of sag rods, base plates, girts, etc.

TABLE 94 UNIT WEIGHT OF PORTAL FRAMES (kg/m²)*

Wind Pressure = 100 kg/m²

Span	Type of Support	No. of Bays	Column Height	Spacing = 4.5 m, Roof Slope			Spacing = 6.0 m, Roof Slope		
(m)			(m)	1 in 3	1 in 4	1 in 5	1 in 3	1 in 4	1 in 5
9.0	Fixed	1	4.5	27.22	27.06	24.23	26.86	26.72	26.67
			6.0	34.38	33.45	33.34	34.93	34.76	34.65
		2	4.5	22.70	22.56	22.50	25.31	25.16	23.32
			6.0	27.23	27.05	26.97	29.22	29.07	23.99
		3	4.5	22.13	22.00	21.91	24.78	23.70	22.88
			6.0	26.30	26.13	26.04	28.40	28.25	28.17
		4	4.5	21.84	21.70	21.62	24.53	24.40	22.66
			6.0	25.84	25.67	25.58	27.99	27.84	27.76
	Hinged	1	4.5	38.33	38.02	37.90	38.89	38.62	38.51
			6.0	56.31	55.88	55.71	55.36	54.97	48.23
		2	4.5	31.22	30.96	30.86	32.62	32.39	32.30
			6.0	43.26	42.90	42.75	43.85	43.53	43.40
		3	4.5	30.25	30.00	29.89	31.77	28.94	28.86
			6.0	41.47	36.51	36.38	37.55	37.28	37.17
		4	4.5	29.76	29.51	29.40	31.34	28.57	28.49
			6.0	36.05	35.74	35.62	36.88	36.61	36.50
12.0	Fixed	1	4.5	24.14	21.98	23.87	25.97	25.81	25.72
			6.0	33.09	29.15	29.03	30.63	30.42	30.33
			9.0	51.11	53.85	53.67	49.68	49.34	49.18

(Continued)

TABLE 94 UNIT WEIGHT OF PORTAL FRAMES (kg/m²)*—Contd.

Wind Pressure = 200 kg/m²

SPAN (m)	TYPE OF SUPPORT	NO. OF BAYS	COLUMN HEIGHT (m)	SPACING = 4.5 m, Roof Slope 1 in 3	SPACING = 4.5 m, Roof Slope 1 in 4	SPACING = 4.5 m, Roof Slope 1 in 5	SPACING = 6.0 m, Roof Slope 1 in 3	SPACING = 6.0 m, Roof Slope 1 in 4	SPACING = 6.0 m, Roof Slope 1 in 5
		2	4.5	22.61	22.41	20.17	26.27	22.92	22.53
			6.0	26.92	26.69	26.59	28.45	25.82	25.74
			9.0	44.26	43.88	43.72	44.26	38.71	38.58
		3	4.5	22.08	21.89	21.80	24.14	23.97	22.15
			6.0	26.10	25.87	25.76	27.73	25.20	25.12
			9.0	37.32	37.00	36.85	37.48	37.20	27.07
		4	4.5	24.16	21.63	21.54	23.92	23.74	23.66
			6.0	25.69	25.47	25.36	27.36	27.16	24.82
			9.0	36.46	33.83	36.00	36.73	36.45	36.32
	Hinged	1	4.5	38.21	33.57	33.43	34.46	34.18	30.05
			6.0	48.85	48.40	48.21	48.20	47.78	47.61
			9.0	—	—	—	—	—	—
		2	4.5	31.32	31.00	27.63	32.20	29.05	28.94
			6.0	44.02	37.83	37.68	38.82	38.48	38.33
			9.0	—	—	—	—	—	—
		3	4.5	30.46	27.01	27.00	31.44	28.41	28.30
			6.0	36.87	36.50	36.34	37.61	37.27	37.13
			9.0	68.84	64.50	64.23	—	—	—
		4	4.5	30.03	29.71	26.53	31.07	28.08	27.98
			6.0	36.20	35.83	35.67	37.00	32.67	32.55
			9.0	63.44	62.80	62.53	—	—	—
18.0	Fixed	1	6.0	28.19	31.39	31.26	28.94	31.76	31.64
			9.0	47.83	47.38	47.17	46.78	46.38	46.19
			12.0	73.09	72.67	72.23	—	63.95	—
		2	6.0	33.18	29.13	28.98	30.04	29.75	29.63
			9.0	37.20	36.82	36.65	37.41	37.07	36.92
			12.0	55.51	54.99	54.73	53.25	52.80	52.56
		3	6.0	28.69	28.37	28.22	29.36	29.08	28.96
			9.0	35.86	35.48	40.74	36.20	35.87	35.71
			12.0	52.95	52.41	52.16	50.98	44.46	44.28
	Hinged	1	6.0	47.86	47.30	47.05	46.48	45.98	40.44
			9.0	—	—	—	—	—	—
			12.0	—	—	—	—	—	—
		2	6.0	38.22	37.74	37.53	38.17	37.75	37.56
			9.0	—	—	—	—	—	—
			12.0	—	—	—	—	—	—
		3	6.0	37.14	35.85	36.45	37.21	36.79	36.60
			9.0	—	—	—	—	—	—
			12.0	—	—	—	—	—	—
24.0	Fixed	1	9.0	49.23	48.70	48.45	47.43	46.95	46.75
			12.0	—	62.99	62.69	—	—	—
		2	9.0	38.88	44.38	44.13	38.52	43.14	42.92
			12.0	56.80	56.18	55.89	—	—	—
	Hinged	1	9.0	—	—	—	—	—	—
			12.0	—	—	—	—	—	—
		2	9.0	—	—	—	—	—	—
			12.0	—	—	—	—	—	—
30.0	Fixed	1	9.0	—	—	—	—	—	—
			12.0	—	—	—	—	—	—
		2	9.0	—	—	—	—	—	—
			12.0	—	—	—	—	—	—

*Unit weight includes weight of structural steel in the frame and purlins only. It does include the weight of sag rods, base plates, girts, etc.

exceptions being normally found in longer span frames having smaller columns heights, where occasionally member strength governs.

b) For 24 and 30 m span frames, it is not possible to design portal frames using hot rolled I-sections without going in for built up sections. There are few exceptions to this in the case of 24 m span length with fixed base. For these two spans only, analysis results for the cases of column and end 1/5 of rafters having twice the moment of inertia of rest of the rafters has also been presented.

c) Generally frames with fixed type of support are lighter compared to frames with hinged type of support. The economy being in the range of 10 percent to as much as 50 percent. Part of this economy, however, may be offset by the additional cost of foundation which has to carry the moment in the case of fixed base frames.

d) In most of the cases, 1 in 5 roof slopes seems to yield lighter frame particularly for shorter span lengths. Whereas in rare occasions, the steeper slope frames seem to be lighter. The variation of weights on the basis of roof slopes is often much less than 10 percent.

e) Frames having 4.5 m spacing are generally lighter particularly in the case of frames with shorter columns, whereas frames having 6.0 m spacing are lighter, if the columns are longer.

f) Generally multiple bay frames are lighter compared to single bay frames. This inference is more appropriate for larger spacing between frames and longer column lengths.

g) In the case of multiple bay frames, the wind load does not seem to influence the deflection and hence the designs vary much.

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TABLE 1 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 9 m | Type of Support : Fixed | No. of Bays : 1

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
4.50	4.50	1 in 3	100	1 550	1 618	0.0262	1 024	1 618	225/23.5	200/25.4	200/28.8	200/37.3
			150	1 550	1 618	0.0395	1 024	1 618	250/27.9	225/31.2	225/33.9	200/37.3
			200	1 550	1 618	0.0549	1 024	1 618	275/33.0	250/37.3	225/33.9	225/43.1
		1 in 4	100	1 653	1 791	0.0231	1 004	1 791	250/27.9	200/25.4	200/28.8	150/34.6
			150	1 653	1 791	0.0364	1 004	1 791	250/27.9	225/31.2	200/28.8	200/37.3
			200	1 653	1 791	0.0503	1 004	1 791	250/27.9	250/37.3	225/33.9	200/37.3
		1 in 5	100	1 719	1 903	0.0221	983	1 903	250/27.9	200/25.4	200/28.8	150/30.6
			150	1 719	1 903	0.0349	983	1 903	250/27.9	225/31.2	200/28.8	200/37.3
			200	1 719	1 903	0.0482	983	1 903	250/27.9	225/31.2	225/33.9	200/37.3
	6.00	1 in 3	100	1 551	1 613	0.0729	862	1 613	275/33.0	250/37.3	225/33.9	225/43.1
			150	1 551	1 613	0.109	862	1 613	300/37.7	300/44.2	250/40.9	250/51.0
			200	1 803	2 497	0.148	862	1 613	325/43.1	300/44.2	300/48.1	250/51.0
		1 in 4	100	1 653	1 755	0.0667	820	1 755	250/27.9	250/37.3	225/33.9	200/37.3
			150	1 653	1 755	0.102	820	1 755	275/33.0	300/44.2	250/40.9	225/43.1
			200	967	2 479	0.139	820	1 755	300/37.7	300/44.2	300/48.1	250/51.0
		1 in 5	100	1 719	1 846	0.0652	785	1 846	250/27.9	225/31.2	225/33.9	200/37.3
			150	1 719	1 846	0.0990	785	1 846	275/33.0	250/37.3	250/40.9	225/43.1
			200	1 074	2 494	0.134	785	1 846	300/37.7	300/44.2	300/48.1	250/51.0

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 2 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 9 m — Type of Support : Fixed — No. of Bays : 1

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
6.00	4.50	1 in 3	100	2 136	2 229	0.0354	1 411	2 229	250/27.9	225/31.2	200/28.8	200/37.3
			150	2 136	2 229	0.0523	1 411	2 229	250/27.9	250/37.3	225/33.9	200/37.3
			200	2 136	2 229	0.0729	1 411	2 229	275/33.0	250/37.3	250/40.9	225/43.1
		1 in 4	100	2 271	2 461	0.0308	1 380	2 461	250/27.9	225/31.2	200/28.8	200/37.3
			150	2 271	2 461	0.0482	1 380	2 461	250/27.9	225/31.2	225/33.9	200/37.3
			200	2 271	2 461	0.0667	1 380	2 461	275/33.0	250/37.3	250/40.9	225/43.1
		1 in 5	100	2 358	2 611	0.0293	1 348	2 611	250/27.9	225/31.2	200/28.8	200/37.3
			150	2 358	2 611	0.0467	1 348	2 611	250/27.9	225/31.2	225/33.9	200/37.3
			200	2 358	2 611	0.0641	1 348	2 611	275/33.0	250/37.3	250/40.9	225/43.1
	6.00	1 in 3	100	2 136	2 222	0.0975	1 188	2 222	275/33.0	250/37.3	250/40.9	225/43.1
			150	2 136	2 222	0.115	1 188	2 222	325/43.1	300/44.2	300/48.1	250/51.0
			200	1 019	3 295	0.197	1 188	2 222	350/49.5	350/52.4	350/56.9	300/58.8
		1 in 4	100	2 271	2 411	0.0888	1 126	2 411	275/33.0	250/37.3	250/40.9	225/43.1
			150	2 271	2 411	0.135	1 126	2 411	300/37.7	300/44.2	300/48.1	250/51.0
			200	1 239	3 272	0.184	1 126	2 411	325/43.1	350/52.4	300/48.1	300/58.8
		1 in 5	100	2 358	2 532	0.0862	1 077	2 532	275/33.0	250/37.3	250/40.9	225/43.1
			150	2 358	2 532	0.132	1 077	2 532	300/37.7	300/44.2	300/48.1	250/51.0
			200	1 382	3 293	0.179	1 077	2 532	325/43.1	350/52.4	300/48.1	300/58.8

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 3 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 12 m | Type of Support : Fixed | No. of Bays : 1

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
4.50	4.50	1 in 3	100	2 096	2 818	0.0328	1 660	2 818	250/27.9	225/31.2	200/28.8	200/37.3
			150	2 096	2 818	0.0482	1 660	2 818	250/27.9	225/31.2	225/33.9	200/37.3
			200	2 096	2 818	0.0688	1 660	2 818	275/33.0	250/37.3	250/40.9	225/43.1
		1 in 4	100	2 232	3 190	0.0262	1 681	3 190	275/33.0	225/31.2	200/28.8	200/37.3
			150	2 232	3 190	0.0441	1 681	3 190	275/33.0	225/31.2	225/33.9	200/37.3
			200	2 232	3 190	0.0631	1 681	3 190	275/33.0	250/37.3	250/40.9	225/43.1
		1 in 5	100	2 320	3 435	0.0251	1 681	3 435	275/33.0	225/31.2	200/28.8	200/37.3
			150	2 320	3 435	0.0421	1 681	3 435	275/33.0	225/31.2	225/33.9	200/37.3
			200	2 320	3 435	0.0595	1 681	3 435	275/33.0	250/37.3	250/40.9	225/43.1
	6.00	1 in 3	100	2 096	2 917	0.0836	1 385	2 917	275/33.0	250/37.3	250/40.9	225/43.1
			150	2 096	2 917	0.125	1 385	2 917	300/37.7	300/44.2	300/48.1	250/51.0
			200	2 096	2 917	0.173	1 385	2 917	325/43.1	350/52.4	300/48.1	300/58.8
		1 in 4	100	2 232	3 226	0.0724	1 357	3 226	300/37.7	250/37.3	225/33.9	225/43.1
			150	2 232	3 226	0.115	1 357	3 226	300/37.7	300/44.2	300/48.1	250/51.0
			200	2 232	3 226	0.159	1 357	3 226	325/43.1	300/44.2	300/48.1	300/58.8
		1 in 5	100	2 320	3 426	0.0703	1 327	3 426	300/37.7	250/37.3	225/33.9	200/40.0
			150	2 320	3 426	0.111	1 327	3 426	300/37.7	300/44.2	250/40.9	250/51.0
			200	2 320	3 426	0.152	1 327	3 426	325/43.1	300/44.2	300/48.1	250/54.7
	9.00	1 in 3	100	2 096	2 875	0.467	1 091	2 875	400/56.9	400/61.6	400/66.7	350/67.4
			150	233	5 706	0.714	1 225	4 784	450/65.3	450/72.4	450/79.4	400/77.4
			200	572	7 834	0.960	1 769	6 736	500/75.0	500/86.9	450/79.4	450/87.2
		1 in 4	100	2 232	3 107	0.442	1 024	3 107	400/56.9	400/61.6	350/56.9	350/67.4
			150	449	5 555	0.673	1 193	5 084	450/65.3	450/72.4	400/66.7	400/77.4
			200	854	7 622	0.875	1 708	7 135	500/75.0	500/86.9	450/79.4	450/87.2
		1 in 5	100	2 320	3 255	0.432	971	3 255	400/56.9	400/61.6	350/56.9	350/67.4
			150	591	5 525	0.655	1 164	5 320	450/65.3	450/72.4	400/66.7	400/77.4
			200	1 040	7 574	0.879	1 658	7 447	500/75.0	450/72.4	450/79.4	450/87.2

Δ = Side sway (cm), I = Moment of inertia (cm^4).

TABLE 4 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 12 m | Type of Support : Fixed | No. of Bays : 1

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
6.00	4.50	1 in 3	100	2 885	3 880	0.0452	2 285	3 880	275/33.0	250/37.3	225/33.9	200/37.3
			150	2 885	3 880	0.0631	2 285	3 880	275/33.0	250/37.3	250/40.9	225/43.1
			200	2 885	3 880	0.0908	2 285	3 880	300/37.7	300/44.2	300/48.1	250/51.0
		1 in 4	100	3 065	4 380	0.0354	2 308	4 380	300/37.7	250/37.3	225/33.9	200/37.3
			150	3 065	4 380	0.0580	2 308	4 380	300/37.7	250/37.3	250/40.9	225/43.1
			200	3 065	4 380	0.0831	2 308	4 380	300/37.7	300/44.2	250/40.9	250/51.0
		1 in 5	100	3 181	4 710	0.0323	2 305	4 710	300/37.7	250/37.3	250/40.9	225/43.1
			150	3 181	4 710	0.0554	2 305	4 710	300/37.7	250/37.3	250/40.9	225/43.1
			200	3 181	4 710	0.0785	2 305	4 710	300/37.7	300/44.2	250/40.9	225/46.8
	6.00	1 in 3	100	2 885	4 016	0.113	1 907	4 016	325/43.1	300/44.2	250/40.9	250/51.0
			150	2 885	4 016	0.165	1 907	4 016	325/43.1	300/44.2	300/48.1	300/58.8
			200	2 885	4 016	0.229	1 907	4 016	350/49.5	350/52.4	350/56.9	300/58.8
		1 in 4	100	3 065	4 430	0.0975	1 863	4 430	325/43.1	300/44.2	250/40.9	225/43.1
			150	3 065	4 430	0.152	1 863	4 430	325/43.1	300/44.2	300/48.1	250/54.7
			200	3 065	4 430	0.211	1 863	4 430	350/49.5	350/52.4	350/56.9	300/58.8
		1 in 5	100	3 181	4 697	0.0929	1 820	4 697	325/43.1	300/44.2	250/40.9	225/43.1
			150	3 181	4 697	0.147	1 820	4 697	325/43.1	300/44.2	300/48.1	250/51.0
			200	3 181	4 697	0.202	1 820	4 697	350/49.5	350/52.4	350/56.9	300/58.8
	9.00	1 in 3	100	99	5 087	0.621	1 502	3 958	450/65.3	450/72.4	400/66.7	400/77.4
			150	242	7 549	0.949	1 598	6 284	500/75.0	500/86.9	450/79.4	450/87.2
			200	694	10 387	1.277	2 324	8 888	550/86.3	500/86.9	500/95.2	—
		1 in 4	100	3 065	4 266	0.588	1 406	4 266	450/65.3	400/61.6	400/66.7	400/77.4
			150	532	7 351	0.896	1 560	6 686	500/75.0	500/86.9	450/79.4	450/87.2
			200	1 072	10 106	1.203	2 247	9 420	550/86.3	500/86.9	500/95.2	—
		1 in 5	100	3 181	4 463	0.575	1 332	4 463	450/65.3	400/61.6	400/66.7	350/72.4
			150	721	7 313	0.873	1 525	7 000	500/75.0	450/72.4	450/79.4	450/87.2
			200	1 321	10 045	1.171	2 183	9 837	550/86.3	500/86.9	500/95.2	450/92.5

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 5 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 18 m — Type of Support : Fixed — No. of Bays : 1

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
4.50	6.00	1 in 3	100	3 229	6 346	0.120	2 756	6 346	350/49.5	350/ 52.4	300/ 48.1	250/51.0
			150	3 229	6 346	0.166	2 756	6 346	350/49.5	350/ 52.4	300/ 48.1	300/58.8
			200	3 229	6 346	0.243	2 756	6 346	350/49.5	350/ 52.4	350/ 56.9	300/63.0
		1 in 4	100	3 431	7 249	0.113	2 826	7 249	350/49.5	400/ 61.6	300/ 48.1	300/58.8
			150	3 431	7 249	0.154	2 826	7 249	350/49.5	400/ 61.6	300/ 48.1	300/58.8
			200	3 431	7 249	0.224	2 826	7 249	350/49.5	400/ 61.6	350/ 56.9	300/58.8
		1 in 5	100	3 562	7 851	0.104	2 850	7 851	400/56.9	400/ 61.6	300/ 48.1	300/58.8
			150	3 562	7 851	0.146	2 850	7 851	400/56.9	400/ 61.6	300/ 48.1	300/58.8
			200	3 562	7 851	0.212	2 850	7 851	400/56.9	400/ 61.6	350/ 56.9	300/58.8
	9.00	1 in 3	100	3 229	6 742	0.551	2 134	6 742	450/65.3	450/ 72.4	400/ 66.7	350/67.4
			150	3 229	6 742	0.872	2 134	6 742	500/75.0	450/ 72.4	450/ 79.4	450/87.2
			200	2 118	9 026	1.194	2 499	9 128	550/ 86.3	500/ 86.9	500/ 95.2	—
		1 in 4	100	3 431	7 441	0.510	2 087	7 441	500/75.0	450/ 72.4	400/ 66.7	350/67.4
			150	3 431	7 441	0.803	2 087	7 441	500/75.0	450/ 72.4	450/ 79.4	400/77.4
			200	2 565	9 083	0.0961	2 558	10 365	500/75.0	500/ 86.9	500/ 95.2	450/87.2
		1 in 5	100	3 562	7 892	0.491	2 039	7 892	500/75.0	500/ 86.9	400/ 66.7	350/67.4
			150	3 562	7 892	0.769	2 039	7 892	500/75.0	500/ 86.9	450/ 79.4	400/77.4
			200	2 852	9 206	0.0462	2 577	11 236	500/75.0	500/ 86.9	500/ 95.2	450/87.2
	12.00	1 in 3	100	3 229	6 721	1.535	1 796	6 721	600/99.5	550/103.7	500/ 95.2	450/92.5
			150	143	10 151	2.363	1 732	8 932	600/99.5	550/103.7	550/112.5	—
			200	603	14 094	3.189	2 539	12 769	—	600/122.6	600/133.7	—
		1 in 4	100	3 431	7 288	1.444	1 703	7 288	600/99.5	550/103.7	500/ 95.2	450/87.2
			150	474	9 889	2.212	1 721	9 686	600/99.5	550/103.7	550/112.5	—
			200	1 035	13 717	2.980	2 495	13 773	—	600/122.6	600/133.7	—
		1 in 5	100	3 562	7 651	1.405	1 628	7 651	600/99.5	550/103.7	500/ 95.2	450/87.2
			150	2 055	9 860	2.147	1 700	10 251	600/99.5	550/103.7	550/112.5	—
			200	3 140	13 660	2.887	2 449	14 526	—	600/122.6	550/112.5	—

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 6 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 18 m | Type of Support : Fixed | No. of Bays : 1

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection					Alternate Design Sections for Beam and Column			
				Column			Beam					
				Axial	Moment	$\Delta I/10^5$	Axial	Moment	ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m^2)	(kg)	(kg. m)	(cm^5)	(kg)	(kg. m)				
6.00	6.00	1 in 3	100	4 442	8 730	0.165	3 791	8 730	400/56.9	400/ 61.6	350/ 56.9	300/58.8
			150	4 442	8 730	0.216	3 791	8 730	400/56.9	400/ 61.6	350/ 56.9	300/58.8
			200	4 442	8 730	0.319	3 791	8 730	400/56.9	400/ 61.6	400/ 66.7	350/67.4
		1 in 4	100	4 709	9 947	0.155	3 879	9 947	450/65.3	450/ 72.4	350/ 56.9	300/58.8
			150	4 709	9 947	0.200	3 879	9 947	450/65.3	450/ 72.4	350/ 56.9	300/58.8
			200	4 709	9 947	0.294	3 879	9 947	450/65.3	450/ 72.4	350/ 56.9	350/67.4
		1 in 5	100	4 882	10 759	0.142	3 906	10 759	450/65.3	450/ 72.4	350/ 56.9	350/67.4
			150	4 882	10 759	0.191	3 906	10 759	450/65.3	450/ 72.4	350/ 56.9	350/67.4
			200	4 882	10 759	0.278	3 906	10 759	450/65.3	450/ 72.4	350/ 56.9	350/67.4
	9.00	1 in 3	100	4 442	9 274	0.730	2 936	9 274	550/86.3	500/ 86.9	450/ 79.4	400/77.4
			150	4 442	9 274	1.155	2 936	9 274	550/86.3	500/ 86.9	500/ 95.2	450/92.5
			200	2 722	11 883	1.584	3 257	11 957	600/ 99.5	550/103.7	550/112.5	—
		1 in 4	100	4 709	10 211	0.674	2 864	10 211	550/86.3	500/ 86.9	450/ 79.4	400/77.4
			150	4 709	10 211	1.0643	2 864	10 211	550/86.3	500/ 86.9	500/ 95.2	450/87.2
			200	3 320	11 965	1.455	3 350	13 602	550/86.3	550/103.7	500/ 95.2	—
		1 in 5	100	4 882	10 815	0.650	2 794	10 815	550/86.3	500/ 86.9	460/ 79.4	400/77.4
			150	4 882	10 815	1.0195	2 794	10 815	550/86.3	500/ 86.9	500/ 95.2	450/87.2
			200	3 703	12 134	1.389	3 380	14 762	550/86.3	550/103.7	500/ 95.2	—
	12.00	1 in 3	100	4 442	9 245	2.0399	2 471	9 245	600/99.5	550/103.7	550/112.5	—
			150	88	13 395	3.140	2 252	11 697	—	600/122.6	600/133.7	—
			200	702	18 653	4.242	3 328	16 813	—	—	600/145.1	—
		1 in 4	100	4 709	10 001	1.917	2 337	10 001	600/99.5	550/103.7	500/ 95.2	—
			150	531	13 054	2.942	2 244	12 702	—	600/122.6	600/133.7	—
			200	1 280	18 157	3.966	3 276	18 151	—	—	600/133.7	—
		1 in 5	100	4 882	10 486	1.867	2 231	10 486	600/99.5	550/103.7	500/ 95.2	—
			150	2 641	13 020	2.856	2 221	13 455	—	600/122.6	550/112.5	—
			200	4 087	18 087	3.843	3 220	19 155	—	—	600/133.7	—

Δ = Side sway (cm), I = Moment of inertia (cm^4).

TABLE 7 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 24 m — Type of Support : Fixed — No. of Bays : 1

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column			Beam		Alternate Design Sections for Beam and Column			
				Axial	Moment	$\Delta I/10^5$	Axial	Moment	ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
4.50	9.00	1 in 3	100	4 419	11 883	0.652	3 498	11 883	—	500/ 86.9	450/ 79.4	400/77.4
			150	4 419	11 883	1.0742	3 498	11 883	—	500/ 86.9	500/ 95.2	450/87.2
			200	4 419	11 883	1.515	3 427	12 289	—	550/103.7	500/ 95.2	—
		1 in 4	100	4 686	13 393	0.597	3 527	13 393	600/99.5	550/103.7	500/ 95.2	400/77.4
			150	4 686	13 393	0.992	3 527	13 393	600/99.5	550/103.7	500/ 95.2	450/87.2
			200	4 686	13 393	1.377	3 692	14 819	600/99.5	550/103.7	500/ 95.2	—
		1 in 5	100	4 860	14 387	0.570	3 519	14 387	600/99.5	550/103.7	500/ 95.2	400/77.4
			150	4 860	14 387	0.936	3 519	14 387	600/99.5	550/103.7	500/ 95.2	450/87.2
			200	4 860	14 387	1.304	3 827	16 572	600/99.5	550/103.7	500/ 95.2	—
	12.00	1 in 3	100	4 419	12 300	1.726	2 920	12 300	—	600/122.6	500/ 95.2	—
			150	4 419	12 300	2.736	2 920	12 300	—	600/122.6	550/112.5	—
			200	2 739	15 864	3.755	3 267	15 985	—	—	600/133.7	—
		1 in 4	100	4 686	13 546	1.598	2 848	13 546	—	600/122.6	500/ 95.2	—
			150	4 686	13 546	2.525	2 848	13 546	—	600/122.6	550/112.5	—
			200	3 336	15 969	3.443	3 358	18 177	—	600/122.6	600/133.7	—
		1 in 5	100	4 860	14 350	1.542	2 779	14 350	—	600/122.6	550/112.5	—
			150	4 860	14 350	2.415	2 779	14 350	—	600/122.6	550/112.5	—
			200	3 720	16 193	3.287	3 386	19 723	—	600/122.6	600/133.7	—

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 8 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 24 m | Type of Support : Fixed | No. of Bays : 1

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
6.00	9.00	1 in 3	100	6 074	16 334	0.881	4 808	16 334	600/99.5	550/103.7	500/ 95.2	450/87.2
			150	6 074	16 334	1.423	4 808	16 334	600/99.5	550/103.7	500/ 95.2	—
			200	6 074	16 334	2.002	4 808	16 334	600/99.5	600/122.6	550/112.5	—
		1 in 4	100	6 427	18 366	0.771	4 837	18 366	—	600/122.6	500/ 95.2	450/87.2
			150	6 427	18 366	1.304	4 837	18 366	—	600/122.6	500/ 95.2	—
			200	6 427	18 366	1.827	4 822	19 377	—	600/122.6	550/112.5	—
		1 in 5	100	6 656	19 705	0.744	4 819	19 705	—	600/122.6	500/ 95.2	—
			150	6 656	19 705	1.230	4 819	19 705	—	600/122.6	500/ 95.2	—
			200	6 656	19 705	1.717	5 007	21 704	—	600/122.6	550/112.5	—
	12.00	1 in 3	100	6 074	16 906	2.323	4 013	16 906	—	600/122.6	550/112.5	—
			150	6 074	16 906	3.627	4 013	16 906	—	—	600/133.7	—
			200	3 516	20 882	4.976	4 265	20 933	—	—	—	—
		1 in 4	100	6 427	18 576	2.122	3 906	18 576	—	—	550/112.5	—
			150	6 427	18 576	3.342	3 906	18 576	—	—	600/133.7	—
			200	4 315	21 035	4.572	4 396	23 850	—	—	—	—
		1 in 5	100	6 656	19 654	2.0382	3 807	19 654	—	—	600/133.7	—
			150	6 656	19 654	3.204	3 807	19 654	—	—	600/133.7	—
			200	4 828	21 341	4.370	4 440	25 907	—	—	600/145.1	—

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 9 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 30 m | Type of Support : Fixed | No. of Bays : 1

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
4.50	9.00	1 in 3	100	5 666	18 020	0.854	5 162	18 020	—	—	500/ 95.2	450/87.2
			150	5 666	18 020	1.340	5 162	18 020	—	—	500/ 95.2	—
			200	5 666	18 020	1.937	5 162	18 020	—	—	550/112.5	—
		1 in 4	100	5 997	20 721	0.817	5 344	20 721	—	—	500/ 95.2	—
			150	5 997	20 721	1.249	5 344	20 721	—	—	500/ 95.2	—
			200	5 997	20 721	1.800	5 344	20 721	—	—	550/112.5	—
		1 in 5	100	6 212	22 549	0.762	5 425	22 549	—	—	550/112.5	—
			150	6 212	22 549	1.184	5 425	22 549	—	—	550/112.5	—
			200	6 212	22 549	1.699	5 362	23 094	—	—	550/112.5	—
	12.00	1 in 3	100	5 666	19 263	1.992	4 308	19 263	—	—	600/133.7	—
			150	5 666	19 263	3.195	4 308	19 263	—	—	600/133.7	—
			200	5 666	19 263	4.480	4 308	19 263	—	—	—	—
		1 in 4	100	5 997	21 547	1.772	4 303	21 547	—	—	600/133.7	—
			150	5 997	21 547	2.929	4 303	21 547	—	—	600/133.7	—
			200	5 997	21 547	4.0857	4 424	23 736	—	—	600/133.7	—
		1 in 5	100	6 212	23 043	1.699	4 267	23 043	—	—	600/133.7	—
			150	6 212	23 043	2.782	4 267	23 043	—	—	600/133.7	—
			200	6 212	23 043	3.866	4 564	26 397	—	—	600/133.7	—

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 10 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 30 m   Type of Support : Fixed   No. of Bays : 2

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^3$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
6.00	9.00	1 in 3	100	7 783	24 751	1.175	7 091	24 751	—	—	550/112.5	—
			150	7 783	24 751	1.754	7 091	24 751	—	—	550/112.5	—
			200	7 783	24 751	2.552	7 091	24 751	—	—	600/133.7	—
		1 in 4	100	8 219	28 397	1.120	7 324	28 397	—	—	550/112.5	—
			150	8 219	28 397	1.634	7 324	28 397	—	—	550/112.5	—
			200	8 219	28 397	2.360	7 324	28 397	—	—	600/133.7	—
		1 in 5	100	8 503	30 865	1.037	7 426	30 865	—	—	600/133.7	—
			150	8 503	30 865	1.552	7 426	30 865	—	—	600/133.7	—
			200	8 503	30 865	2.231	7 426	30 865	—	—	600/133.7	—
	12.00	1 in 3	100	7 783	26 458	2.708	5 917	26 458	—	—	600/145.1	—
			150	7 783	26 458	4.214	5 917	26 458	—	—	600/145.1	—
			200	7 783	26 458	5.922	5 917	26 458	—	—	—	—
		1 in 4	100	8 219	29 530	2.323	5 897	29 530	—	—	600/145.1	—
			150	8 219	29 530	3.865	5 897	29 530	—	—	600/145.1	—
			200	8 219	29 530	5.408	5 779	31 049	—	—	—	—
		1 in 5	100	8 503	31 541	2.231	5 841	31 541	—	—	600/145.1	—
			150	8 503	31 541	3.673	5 841	31 541	—	—	600/145.1	—
			200	8 503	31 541	5.114	5 972	34 583	—	—	—	—

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 11 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 9 m   Type of Support : Fixed   No. of Bays : 2

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection					Alternate Design Sections for Beam and Column			
				Column			Beam					
				Axial	Moment	$\Delta I/10^5$	Axial	Moment	ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
4.50	4.50	1 in 3	100	1 508	1 567	0.0251	1 057	1 954	225/23.5	200/25.4	200/28.8	200/37.3
			150	1 508	1 567	0.0339	1 057	1 954	225/23.5	225/31.2	200/28.8	200/37.3
			200	1 508	1 567	0.0426	1 057	1 954	250/27.9	225/31.2	225/33.9	200/37.3
		1 in 4	100	1 589	1 697	0.0221	1 021	2 269	225/23.5	200/25.4	175/22.1	150/30.6
			150	1 589	1 697	0.0293	1 021	2 269	225/23.5	200/25.4	200/28.8	200/37.3
			200	1 589	1 697	0.0369	1 021	2 269	250/27.9	225/31.2	200/28.8	200/37.3
		1 in 5	100	1 640	1 772	0.0200	984	2 482	250/27.9	200/25.4	175/22.1	150/27.1
			150	1 640	1 772	0.0272	984	2 482	250/27.9	200/25.4	200/28.8	200/37.3
			200	1 640	1 772	0.0354	984	2 482	250/27.9	225/31.2	200/28.8	200/37.3
	6.00	1 in 3	100	1 469	1 489	0.0585	875	2 221	250/27.9	225/31.2	225/33.9	200/37.3
			150	1 469	1 489	0.0826	875	2 221	275/33.0	250/37.3	250/40.9	225/43.1
			200	1 271	2 007	0.107	875	2 221	300/37.7	300/44.2	250/40.9	250/51.0
		1 in 4	100	1 549	1 578	0.0529	817	2 514	250/27.9	225/31.2	225/33.9	200/37.3
			150	1 549	1 578	0.0754	817	2 514	275/33.0	250/37.3	225/33.9	225/43.1
			200	1 549	1 578	0.0980	817	2 514	275/33.0	250/37.3	250/40.9	225/43.1
		1 in 5	100	1 600	1 630	0.0503	768	2 705	250/27.9	225/31.2	200/28.8	200/37.3
			150	1 600	1 630	0.0718	768	2 705	250/27.9	250/37.3	225/33.9	200/40.0
			200	1 600	1 630	0.0960	768	2 705	275/33.0	250/37.3	250/40.9	225/43.1

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 12 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 9 m | Type of Support : Fixed | No. of Bays : 2

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection					Alternate Design Sections for Beam and Column			
				Column			Beam					
				Axial	Moment	$\Delta I/10^5$	Axial	Moment	ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
6.00	4.50	1 in 3	100	2 076	2 158	0.0344	1 455	2 691	250/27.9	225/31.2	200/28.8	200/37.3
			150	2 076	2 158	0.0462	1 455	2 691	250/27.9	225/31.2	225/33.9	200/37.3
			200	2 076	2 158	0.0575	1 455	2 691	275/33.0	250/37.3	250/40.9	225/43.1
		1 in 4	100	2 183	2 331	0.0298	1 403	3 118	250/27.9	225/31.2	200/28.8	200/37.3
			150	2 183	2 331	0.0400	1 403	3 118	250/27.9	225/31.2	225/33.9	200/37.3
			200	2 183	2 331	0.0503	1 403	3 118	250/27.9	250/37.3	225/33.9	200/37.3
		1 in 5	100	2 250	2 431	0.0272	1 350	3 405	250/27.9	225/31.2	200/28.8	200/37.3
			150	2 250	2 431	0.0369	1 350	3 405	250/27.9	225/31.2	200/28.8	200/37.3
			200	2 250	2 431	0.0472	1 350	3 405	250/27.9	225/31.2	225/33.9	200/37.3
	6.00	1 in 3	100	2 024	2 050	0.07900	1 206	3 059	275/33.0	250/37.3	250/40.9	225/43.1
			150	2 024	2 050	0.111	1 206	3 059	300/37.7	300/44.2	250/40.9	250/51.0
			200	2 088	2 090	0.144	1 206	3 059	325/43.1	300/44.2	300/48.1	250/51.0
		1 in 4	100	2 128	2 168	0.0713	1 122	3 453	275/33.0	250/37.3	225/33.9	200/40.0
			150	2 128	2 168	0.101	1 122	3 453	275/33.0	300/44.2	250/40.9	225/43.1
			200	2 128	2 168	0.131	1 122	3 453	300/37.7	300/44.2	300/48.1	250/51.0
		1 in 5	100	2 194	2 236	0.0677	1 054	3 711	275/33.0	250/37.3	225/33.9	200/37.3
			150	2 194	2 236	0.0965	1 054	3 711	275/33.0	250/37.3	250/40.9	225/43.1
			200	2 194	2 236	0.127	1 054	3 711	300/37.7	300/44.2	300/48.1	250/51.0

Δ = Side sway (cm), I = Moment of inertia (cm^4).

TABLE 13 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 12 m | Type of Support : Fixed | No. of Bays : 2

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
4.50	4.50	1 in 3	100	2 081	2 818	0.0400	1 752	2 994	250/27.9	225/31.2	225/33.9	200/37.3
			150	2 081	2 818	0.0503	1 752	2 994	250/27.9	250/37.3	225/33.9	200/37.3
			200	2 081	2 818	0.0611	1 752	2 994	275/33.0	250/37.3	250/40.9	225/43.1
		1 in 4	100	2 195	3 144	0.0375	1 763	3 586	275/33.0	225/31.2	200/28.8	200/37.3
			150	2 195	3 144	0.0416	1 763	3 586	275/33.0	225/31.2	225/33.9	200/37.3
			200	2 195	3 144	0.0503	1 763	3 586	275/33.0	250/37.3	225/33.9	200/37.3
		1 in 5	100	2 264	3 340	0.0339	1 743	4 003	275/33.0	225/31.2	200/28.8	200/37.3
			150	2 264	3 340	0.0370	1 743	4 003	275/33.0	225/31.2	200/28.8	200/37.3
			200	2 264	3 340	0.0457	1 743	4 003	275/33.0	225/31.2	225/33.9	200/37.3
	6.00	1 in 3	100	2 037	2 825	0.0811	1 429	3 521	275/33.0	250/37.3	250/40.9	225/43.1
			150	2 037	2 825	0.108	1 429	3 521	300/37.7	300/44.2	250/40.9	250/51.0
			200	2 037	2 825	0.136	1 429	3 521	300/37.7	300/44.2	300/48.1	250/51.0
		1 in 4	100	2 146	3 056	0.0698	1 380	4 086	300/37.7	250/37.3	225/33.9	200/37.3
			150	2 146	3 056	0.0934	1 380	4 086	300/37.7	250/37.3	250/40.9	225/43.1
			200	2 146	3 056	0.118	1 380	4 086	300/37.7	300/44.2	300/48.1	250/51.0
		1 in 5	100	2 213	3 189	0.0636	1 329	4 466	300/37.7	250/37.3	225/33.9	200/37.3
			150	2 213	3 189	0.0862	1 329	4 466	300/37.7	250/37.3	250/40.9	225/43.1
			200	2 213	3 189	0.1124	1 329	4 466	300/37.7	300/44.2	250/40.9	250/51.0
	9.00	1 in 3	100	1 963	2 589	0.351	1 105	4 188	350/49.5	350/52.4	350/56.9	300/58.8
			150	295	4 428	0.510	1 105	4 188	400/56.9	400/61.6	400/66.7	350/67.4
			200	638	5 675	0.668	1 105	4 188	450/65.3	450/72.4	400/66.7	400/77.4
		1 in 4	100	2 068	2 725	0.324	1 016	4 694	350/49.5	350/52.4	350/56.9	300/58.8
			150	334	4 092	0.473	1 016	4 694	400/56.9	400/61.6	400/66.7	350/67.4
			200	347	5 516	0.636	1 016	4 694	450/65.3	450/72.4	400/66.7	400/77.4
		1 in 5	100	2 135	2 804	0.311	946	5 023	350/49.5	350/52.4	350/56.9	300/58.8
			150	232	3 998	0.463	946	5 023	400/56.9	400/61.6	400/66.7	350/67.4
			200	541	5 526	0.624	946	5 023	450/65.3	450/72.4	400/66.7	400/77.4

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 14 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 12 m | Type of Support : Fixed | No. of Bays : 2

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
6.00	4.50	1 in 3	100	2 865	3 878	0.0554	2 412	4 122	275/33.0	250/37.3	225/33.9	225/43.1
			150	2 865	3 878	0.0688	2 412	4 122	275/33.0	250/37.3	250/40.9	225/43.1
			200	2 865	3 878	0.0826	2 412	4 122	300/37.7	300/44.2	250/40.9	250/51.0
		1 in 4	100	3 014	4 317	0.0513	2 420	4 924	300/37.7	250/37.3	225/33.9	200/37.3
			150	3 014	4 317	0.0570	2 420	4 924	300/37.7	250/37.3	250/40.9	225/43.1
			200	3 014	4 317	0.0683	2 420	4 924	300/37.7	250/37.3	250/40.9	225/43.1
		1 in 5	100	3 105	4 580	0.0467	2 390	5 489	300/37.7	250/37.3	225/33.9	200/37.3
			150	3 105	4 580	0.0508	2 390	5 489	300/37.7	250/37.3	225/33.9	200/37.3
			200	3 105	4 580	0.0606	2 390	5 489	300/37.7	250/37.3	250/40.9	225/43.1
	6.00	1 in 3	100	2 805	3 889	0.1103	1 968	4 847	300/37.7	300/44.2	250/40.9	250/51.0
			150	2 805	3 889	0.146	1 968	4 848	325/43.1	300/44.2	300/48.1	250/51.0
			200	2 805	3 889	0.183	1 968	4 848	325/43.1	350/52.4	300/48.1	300/58.8
		1 in 4	100	2 947	4 196	0.0949	1 895	5 611	325/43.1	300/44.2	250/40.9	225/43.1
			150	2 947	4 196	0.125	1 895	5 611	325/43.1	300/44.2	300/48.1	250/51.0
			200	2 947	4 196	0.160	1 895	5 611	325/43.1	300/44.2	300/48.1	300/58.8
		1 in 5	100	3 035	4 373	0.0667	1 823	6 125	325/43.1	300/44.2	250/40.9	225/43.1
			150	3 035	4 373	0.117	1 823	6 125	325/43.1	300/44.2	300/48.1	250/51.0
			200	3 035	4 373	0.148	1 823	6 125	325/43.1	300/44.2	300/48.1	250/51.0
	9.00	1 in 3	100	2 702	3 565	0.471	1 521	5 766	400/56.9	400/61.6	400/66.7	350/67.4
			150	329	5 963	0.682	1 521	5 766	450/65.3	450/72.4	450/79.4	400/77.4
			200	786	7 627	0.893	1 521	5 766	500/75.0	500/86.9	450/79.4	450/87.2
		1 in 4	100	2 840	3 742	0.434	1 395	6 446	400/56.9	400/61.6	350/56.9	350/67.4
			150	384	5 510	0.632	1 395	6 446	450/65.3	450/72.4	400/66.7	400/77.4
			200	400	7 300	0.846	1 395	6 446	500/75.0	450/72.4	450/79.4	450/87.2
		1 in 5	100	2 927	3 845	0.418	1 297	6 888	400/56.9	400/61.6	350/56.9	350/67.4
			150	404	5 313	0.615	1 297	6 888	450/65.3	450/72.4	400/66.7	400/77.4
			200	661	7 317	0.830	1 297	6 888	500/75.0	450/72.4	450/79.4	400/82.2

Δ = Side sway (cm), I = Moment of inertia (cm^4).

TABLE 15 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 18 m Type of Support : Fixed No. of Bays : 2

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column			Beam		Alternate Design Sections for Beam and Column			
				Axial	Moment	$\Delta I/10^5$	Axial	Moment	ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
4.50	6.00	1 in 3	100	3 228	6 391	0.182	2 937	6 402	350/49.5	450/ 72.4	300/ 48.1	300/58.8
			150	3 228	6 391	0.199	2 937	6 402	350/49.5	450/ 72.4	350/ 56.9	300/58.8
			200	3 228	6 391	0.235	2 937	6 402	350/49.5	450/ 72.4	350/ 56.9	300/58.8
		1 in 4	100	3 402	7 230	0.175	3 004	7 757	350/49.5	400/ 61.6	300/ 48.1	300/58.8
			150	3 402	7 230	0.175	3 004	7 757	350/49.5	400/ 61.6	300/ 48.1	300/58.8
			200	3 402	7 230	0.191	3 004	7 757	350/49.5	400/ 61.6	350/ 56.9	300/58.8
		1 in 5	100	3 507	7 746	0.163	3 004	8 737	400/56.9	400/ 61.6	300/ 48.1	300/58.8
			150	3 507	7 746	0.163	3 004	8 737	400/56.9	400/ 61.6	300/ 48.1	300/58.8
			200	3 507	7 746	0.166	3 004	8 737	400/56.9	400/ 61.6	350/ 48.1	300/58.8
	9.00	1 in 3	100	3 140	6 529	0.509	2 203	8 137	450/65.3	450/ 72.4	400/ 66.7	350/67.4
			150	3 140	6 529	0.695	2 203	8 137	450/65.3	450/ 72.4	450/ 79.4	400/77.4
			200	3 140	6 529	0.880	2 203	8 137	500/75.0	450/ 72.4	450/ 79.4	450/87.2
		1 in 4	100	3 299	7 048	0.441	2 123	9 423	500/75.0	450/ 72.4	400/ 66.7	350/67.4
			150	3 299	7 048	0.604	2 123	9 423	500/75.0	450/ 72.4	450/ 66.7	400/77.4
			200	3 299	7 048	0.804	2 123	9 423	500/75.0	450/ 72.4	450/ 79.4	400/77.4
		1 in 5	100	3 399	7 347	0.405	2 042	10 288	500/75.0	450/ 72.4	400/ 66.7	350/67.4
			150	3 399	7 347	0.558	2 042	10 288	500/75.0	450/ 72.4	400/ 66.7	350/72.4
			200	3 399	7 347	0.786	2 042	10 288	500/75.0	450/ 72.4	450/ 79.4	400/77.4
	12.00	1 in 3	100	3 059	6 195	1.213	1 824	9 264	600/99.5	550/103.7	450/ 79.4	450/87.2
			150	453	8 150	1.734	1 824	9 264	600/99.5	550/103.7	500/ 95.2	—
			200	995	10 282	2.254	1 824	9 264	600/99.5	550/103.7	550/112.5	—
		1 in 4	100	3 214	6 546	1.0995	1 696	10 451	600/99.5	550/103.7	450/ 79.4	400/82.2
			150	3 214	6 546	1.581	1 696	10 451	600/99.5	550/103.7	500/ 95.2	—
			200	367	9 785	2.121	1 696	10 451	600/99.5	550/103.7	550/112.5	—
		1 in 5	100	3 313	6 748	1.0471	1 592	11 228	600/99.5	550/103.7	450/ 79.4	400/77.4
			150	3 313	6 748	1.530	1 592	11 228	600/99.5	550/103.7	500/ 95.2	450/92.5
			200	2 448	9 939	2.0760	1 592	11 228	600/99.5	550/103.7	550/112.5	—

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 16 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 18 m — Type of Support : Fixed — No. of Bays : 2

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
6.00	6.00	1 in 3	100	4 441	8 792	0.250	4 040	8 807	400/56.9	450/ 72.4	350/ 56.9	300/63.0
			150	4 441	8 792	0.273	4 040	8 807	400/56.9	450/ 72.4	350/ 56.9	350/67.4
			200	4 441	8 792	0.321	4 040	8 807	400/56.9	450/ 72.4	400/ 66.7	350/67.4
		1 in 4	100	4 668	9 922	0.240	4 123	10 645	450/65.3	450/ 72.4	350/ 56.9	300/58.8
			150	4 668	9 922	0.240	4 123	10 645	450/65.3	450/ 72.4	350/ 56.9	300/58.8
			200	4 668	9 922	0.261	4 123	10 645	450/65.3	450/ 72.4	350/ 56.9	350/67.4
		1 in 5	100	4 806	10 616	0.223	4 117	11 974	450/65.3	450/ 72.4	350/ 56.9	300/58.8
			150	4 806	10 616	0.223	4 117	11 974	450/65.3	450/ 72.4	350/ 56.9	300/58.8
			200	4 806	10 616	0.227	4 117	11 974	450/65.3	450/ 72.4	350/ 56.9	300/58.8
	9.00	1 in 3	100	4 319	8 982	0.692	3 031	11 194	500/75.0	500/ 86.9	450/ 79.4	400/77.4
			150	4 319	8 982	0.939	3 031	11 194	500/75.0	500/ 86.9	450/ 79.4	450/87.2
			200	4 319	8 982	0.186	3 031	11 194	550/86.3	500/ 86.9	500/ 95.2	—
		1 in 4	100	4 528	9 672	0.597	2 913	12 931	550/86.3	500/ 86.9	450/ 79.4	400/77.4
			150	4 528	9 672	0.815	2 913	12 931	550/86.3	500/ 86.9	450/ 79.4	400/77.4
			200	4 528	9 672	1.0625	2 913	12 931	550/86.3	500/ 86.9	500/ 95.2	450/87.2
		1 in 5	100	4 658	10 069	0.549	2 799	14 099	550/86.3	500/ 86.9	450/ 79.4	350/67.4
			150	4 658	10 069	0.155	2 799	14 099	550/86.3	500/ 86.9	450/ 79.7	400/77.4
			200	4 658	10 069	1.0410	2 799	14 099	550/86.3	500/ 86.9	500/ 95.2	450/87.2
	12.00	1 in 3	100	4 207	8 523	1.631	2 509	12 743	600/99.5	550/103.7	500/ 95.2	—
			150	506	11 011	2.326	2 509	12 743	600/99.5	550/103.7	550/112.5	—
			200	1 229	13 854	3.0199	2 509	12 743	—	600/122.6	600/133.7	—
		1 in 4	100	4 411	8 982	1.476	2 328	14 341	600/99.5	550/103.7	500/ 95.2	450/87.2
			150	593	10 002	2.120	2 328	14 341	600/99.5	550/103.7	550/112.5	—
			200	396	12 915	2.817	2 328	14 341	600/99.5	600/122.6	550/112.5	—
		1 in 5	100	4 541	9 248	1.405	2 182	15 388	600/99.5	550/103.7	500/ 95.2	450/87.2
			150	4 541	9 248	2.0304	2 182	15 388	600/99.5	550/103.7	550/112.5	—
			200	3 172	13 128	2.759	2 182	15 388	—	600/122.6	550/112.5	—

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 17 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 24 m — Type of Support : Fixed — No. of Bays : 2

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column			Design Forces and Sway Deflection: Beam		Alternate Design Sections for Beam and Column			
				Axial	Moment	$\Delta I/10^5$	Axial	Moment	ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
4.50	9.00	1 in 3	100	4 387	11 875	0.790	3 691	12 637	550/86.3	500/ 86.9	450/ 79.4	400/77.4
			150	4 387	11 875	1.010	3 691	12 637	550/86.3	500/ 86.9	450/ 79.4	450/87.2
			200	4 387	11 875	1.230	3 691	12 637	550/86.3	500/86.9	500/ 95.2	—
		1 in 4	100	4 608	13 196	0.652	3 697	15 069	600/99.5	550/103.7	500/ 95.2	400/77.4
			150	4 608	13 196	0.830	3 697	15 069	600/99.5	550/103.7	500/ 95.2	400/82.2
			200	4 608	13 196	1.028	3 697	15 069	600/99.5	550/103.7	500/ 95.2	450/87.2
		1 in 5	100	4 743	13 986	0.578	3 646	16 782	600/99.5	550/103.7	500/ 95.2	400/77.4
			150	4 743	13 986	0.735	3 646	16 782	600/99.5	550/103.7	500/ 95.2	400/77.4
			200	4 743	13 986	1.019	3 646	16 782	600/99.5	550/103.7	500/ 95.2	450/87.2
	12.00	1 in 3	100	4 297	11 911	1.634	3 013	14 850	—	550/103.7	500/ 95.2	—
			150	4 297	11 911	2.222	3 013	14 850	—	550/103.7	550/112.5	—
			200	940	12 381	2.800	3 013	14 850	—	600/122.6	550/112.5	—
		1 in 4	100	4 506	12 831	1.405	2 897	17 158	—	600/122.6	500/ 95.2	450/92.5
			150	4 506	12 831	1.928	2 897	17 158	—	600/122.6	500/ 95.2	—
			200	4 506	12 831	2.516	2 897	17 158	—	600/122.6	550/112.5	—
		1 in 5	100	4 637	13 361	1.295	2 783	18 711	—	600/122.6	500/ 95.2	—
			150	4 637	13 361	1.781	2 783	18 711	—	600/122.6	500/ 95.2	—
			200	4 637	13 361	2.461	2 783	18 711	—	600/122.6	550/113.5	—

Δ = Side sway (cm), I = Moment of inertia (cm^4).

TABLE 18 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 24 m | Type of Support : Fixed | No. of Bays : 2

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
6.00	9.00	1 in 3	100	6 031	16 323	1.074	5 074	17 370	600/99.5	550/103.7	500/ 95.2	450/87.2
			150	6 031	16 323	1.368	5 074	17 370	600/99.5	550/103.7	500/ 95.2	—
			200	6 031	16 323	1.662	5 074	17 370	600/99,5	550/103.7	550/112.5	—
		1 in 4	100	6 320	18 096	0.900	5 069	20 665	—	600/122.6	500/ 95.2	450/87.2
			150	6 320	18 096	1.129	5 069	20 665	—	600/122.6	500/ 95.2	450/87.2
			200	6 320	18 096	1.368	5 069	20 665	—	600/122.6	500/ 95.2	—
		1 in 5	100	6 496	19 155	0.790	4 994	22 985	—	600/122.6	500/ 95.2	450/92.5
			150	6 496	19 155	1.0008	4 994	22 985	—	600/122.6	500/ 95.2	450/92.5
			200	6 496	19 155	1.340	4 994	22 985	—	600/122.6	500/ 95.2	—
	12.00	1 in 3	100	5 906	16 373	2.263	4 141	20 412	—	600/122.6	550/112.5	—
			150	5 906	16 373	2.993	4 141	20 412	—	600/122.6	600/133.7	—
			200	5 906	16 373	3.774	4 141	20 412	—	—	600/133.7	—
		1 in 4	100	6 179	17 596	1.910	3 972	23 530	—	—	550/112.5	—
			150	6 179	17 596	2.598	3 972	23 530	—	—	550/112.5	—
			200	6 179	17 596	3.324	3 972	23 530	—	—	600/133.7	—
		1 in 5	100	6 350	18 299	1.754	3 812	25 627	—	—	550/112.5	—
			150	6 350	18 299	2.406	3 812	25 627	—	—	550/112.5	—
			200	6 350	18 299	3.259	3 812	25 627	—	—	600/133.7	—

Δ = Side sway (cm), I = Moment of inertia (cm^4).

TABLE 19 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 9 m | Type of Support : Fixed | No. of Bays : 3

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
4.50	4.50	1 in 3	100	1 544	1 673	0.0267	1 165	1 793	225/23.5	200/25.4	200/28.8	200/37.3
			150	1 544	1 673	0.0349	1 165	1 793	225/23.5	225/31.2	200/28.8	200/37.3
			200	1 544	1 673	0.0431	1 165	1 793	250/27.9	225/31.2	225/33.9	200/37.3
		1 in 4	100	1 626	1 811	0.0231	1 116	2 083	250/27.9	200/25.4	200/28.8	150/34.6
			150	1 626	1 811	0.0303	1 116	2 083	250/27.9	200/25.4	200/28.8	200/37.3
			200	1 626	1 811	0.0375	1 116	2 083	250/27.9	225/31.2	200/28.8	200/37.3
		1 in 5	100	1 676	1 886	0.0210	1 044	2 278	250/27.9	200/25.4	175/22.1	150/27.1
			150	1 676	1 886	0.0277	1 044	2 278	250/27.9	200/25.4	200/28.8	200/37.3
			200	1 676	1 886	0.0344	1 044	2 278	250/27.9	225/31.2	200/28.8	200/37.3
	6.00	1 in 3	100	1 505	1 599	0.0549	908	2 006	250/27.9	225/31.2	225/33.9	200/37.3
			150	1 505	1 599	0.0754	908	2 006	275/33.0	250/37.3	225/33.9	225/43.1
			200	1 505	1 599	0.0965	908	2 006	275/33.0	250/37.3	250/40.9	225/43.1
		1 in 4	100	1 585	1 689	0.0488	852	2 305	250/27.9	225/31.2	200/28.8	200/37.3
			150	1 585	1 689	0.0683	852	2 305	250/27.9	250/37.3	225/33.9	200/37.3
			200	1 585	1 689	0.0878	852	2 305	275/33.0	250/37.3	250/40.9	225/43.1
		1 in 5	100	1 634	1 738	0.0462	803	2 502	250/27.9	225/31.2	200/28.8	200/37.3
			150	1 634	1 738	0.0647	803	2 502	250/27.9	225/31.2	225/33.9	200/37.3
			200	1 634	1 738	0.0836	803	2 502	275/33.0	250/37.3	250/40.9	225/43.1

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 20 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 9 m | Type of Support : Fixed | No. of Bays : 3

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection					Alternate Design Sections for Beam and Column			
				Column			Beam					
				Axial	Moment	$\Delta I/10^5$	Axial	Moment	ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
6.00	4.50	1 in 3	100	2 127	2 305	0.0364	1 604	2 470	250/27.9	225/31.2	200/28.8	200/37.3
			150	2 127	2 305	0.0472	1 604	2 470	250/27.9	225/31.2	225/33.9	200/37.3
			200	2 127	2 305	0.0585	1 604	2 470	275/33.0	250/37.3	250/40.9	225/43.1
		1 in 4	100	2 234	2 488	0.0313	1 534	2 861	250/27.9	225/31.2	200/28.8	200/37.3
			150	2 234	2 488	0.0411	1 534	2 861	250/27.9	225/31.2	225/33.9	200/37.3
			200	2 234	2 488	0.0508	1 534	2 861	250/27.9	250/37.3	225/33.9	200/37.3
		1 in 5	100	2 298	2 587	0.0287	1 432	3 125	250/27.9	225/31.2	200/28.8	200/37.3
			150	2 298	2 587	0.0375	1 432	3 125	250/27.9	225/31.2	200/28.8	200/37.3
			200	2 298	2 587	0.0467	1 432	3 125	250/27.9	225/31.2	225/33.9	200/37.3
	6.00	1 in 3	100	2 073	2 203	0.0744	1 251	2 763	275/33.0	250/37.3	225/33.9	225/43.1
			150	2 073	2 203	0.1021	1 251	2 763	275/33.0	300/44.2	250/40.9	225/43.1
			200	2 073	2 203	0.1303	1 251	2 763	300/37.7	300/44.2	300/48.1	250/51.0
		1 in 4	100	2 177	2 320	0.0662	1 170	3 166	275/33.0	225/31.2	225/33.9	200/37.3
			150	2 177	2 320	0.0919	1 170	3 166	275/33.0	250/37.3	250/40.9	225/43.1
			200	2 177	2 320	0.118	1 170	3 166	300/37.7	300/44.2	300/48.1	250/51.0
		1 in 5	100	2 242	2 384	0.0621	1 101	3 432	275/33.0	250/37.3	225/33.9	200/37.3
			150	2 242	2 384	0.0867	1 101	3 432	275/33.0	250/37.3	250/40.9	225/43.1
			200	2 242	2 384	0.112	1 101	3 432	300/37.7	300/44.2	250/40.9	250/51.0

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 21 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 12 m | Type of Support : Fixed | No. of Bays : 3

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
4.50	4.50	1 in 3	100	2 130	3 056	0.0503	1 879	2 976	275/33.0	250/37.3	225/33.9	200/37.3
			150	2 130	3 056	0.0585	1 879	2 976	275/33.0	250/37.3	250/40.9	225/43.1
			200	2 130	3 056	0.0698	1 879	2 976	275/33.0	250/37.3	250/40.9	225/43.1
		1 in 4	100	2 247	3 338	0.0488	2 036	3 334	275/33.0	225/31.2	225/33.9	200/37.3
			150	2 247	3 338	0.0498	2 036	3 334	275/33.0	225/31.2	225/33.9	200/37.3
			200	2 247	3 338	0.0590	2 036	3 334	275/33.0	250/37.3	250/40.9	225/43.1
		1 in 5	100	2 316	3 547	0.0452	2 002	3 731	275/33.0	250/37.3	225/33.9	200/37.3
			150	2 316	3 547	0.0452	2 002	3 731	275/33.0	250/37.3	225/33.9	200/37.3
			200	2 316	3 547	0.0529	2 002	3 731	275/33.0	250/37.3	225/33.9	200/40.0
	6.00	1 in 3	100	2 088	3 019	0.0857	1 578	3 229	300/37.7	250/37.3	250/40.9	225/43.1
			150	2 088	3 019	0.111	1 578	3 229	300/37.7	300/44.2	250/40.9	250/51.0
			200	2 088	3 019	0.138	1 578	3 229	300/37.7	300/44.2	300/48.1	250/51.0
		1 in 4	100	2 196	3 265	0.0739	1 512	3 747	300/37.7	250/37.3	225/33.9	225/43.1
			150	2 196	3 265	0.0965	1 512	3 747	300/37.7	250/37.3	250/40.9	225/43.1
			200	2 196	3 265	0.120	1 512	3 747	300/37.7	300/44.2	300/48.1	250/51.0
		1 in 5	100	2 262	3 398	0.0667	1 412	4 094	300/37.7	250/37.3	225/33.9	200/37.3
			150	2 262	3 398	0.0883	1 412	4 094	300/37.7	250/37.3	250/40.9	225/43.1
			200	2 262	3 398	0.110	1 412	4 094	300/37.7	300/44.2	250/40.9	250/51.0
	9.00	1 in 3	100	2 012	2 789	0.310	1 139	3 798	350/49.5	350/52.4	350/56.9	300/58.8
			150	2 280	3 176	0.442	835	4 122	400/56.9	400/61.6	350/56.9	350/67.4
			200	7 421	5 028	0.575	973	5 030	450/65.3	400/61.6	400/66.7	350/72.4
		1 in 4	100	2 116	2 922	0.284	1 053	4 308	325/43.1	350/52.4	300/48.1	300/58.8
			150	2 267	3 011	0.407	1 053	4 308	400/56.9	400/61.6	350/56.9	350/67.4
			200	2 498	4 007	0.532	1 053	4 308	400/56.9	400/61.6	400/66.7	350/67.4
		1 in 5	100	2 183	2 995	0.271	983	4 641	325/43.1	350/52.4	300/48.1	300/58.8
			150	2 261	2 942	0.392	983	4 641	400/56.9	350/52.4	350/56.9	350/67.4
			200	486	4 801	0.516	983	4 641	400/56.9	400/61.6	400/66.7	350/67.4

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 22 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 12 m | Type of Support : Fixed | No. of Bays : 3

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
6.00	4.50	1 in 3	100	2 933	4 207	0.0693	2 587	4 098	275/33.0	250/37.3	250/40.9	225/43.1
			150	2 933	4 207	0.0801	2 587	4 098	300/37.7	300/44.2	250/40.9	250/51.0
			200	2 933	4 207	0.0949	2 587	4 098	300/37.7	300/44.2	300/48.1	250/51.0
		1 in 4	100	3 086	4 584	0.0667	2 796	4 579	300/37.7	250/37.3	250/40.9	225/43.1
			150	3 086	4 584	0.0683	2 796	4 579	300/37.7	250/37.3	250/40.9	225/43.1
			200	3 086	4 584	0.0811	2 796	4 579	300/37.7	300/44.2	250/40.9	250/51.0
		1 in 5	100	3 175	4 865	0.0621	2 746	5 117	300/37.7	250/37.3	250/40.9	225/43.1
			150	3 175	4 865	0.0621	2 746	5 117	300/37.7	250/37.3	250/40.9	225/43.1
			200	3 175	4 865	0.0724	2 746	5 117	300/37.7	250/37.3	250/40.9	225/43.1
	6.00	1 in 3	100	2 875	4 157	0.118	2 173	4 446	325/43.1	300/44.2	300/48.1	250/51.0
			150	2 875	4 157	0.151	2 173	4 446	325/43.1	300/44.2	300/48.1	250/54.7
			200	2 875	4 157	0.186	2 173	4 446	325/43.1	350/52.4	300/48.1	300/58.8
		1 in 4	100	3 016	4 483	0.101	2 076	5 146	325/43.1	300/44.2	250/40.9	225/43.1
			150	3 016	4 483	0.131	2 076	5 146	325/43.1	300/44.2	300/48.1	250/51.0
			200	3 016	4 483	0.162	2 076	5 146	325/43.1	300/44.2	300/48.1	300/58.8
		1 in 5	100	3 102	4 659	0.0913	1 936	5 614	325/43.1	300/44.2	250/40.9	225/43.1
			150	3 102	4 659	0.120	1 936	5 614	325/43.1	300/44.2	300/48.1	250/51.0
			200	3 102	4 659	0.148	1 936	5 614	325/43.1	300/44.2	300/48.1	250/51.0
	9.00	1 in 3	100	2 770	3 839	0.418	1 569	5 230	400/56.9	400/61.6	350/56.9	350/67.4
			150	3 179	4 240	0.594	1 569	5 230	450/65.3	450/72.4	400/66.7	400/77.4
			200	3 482	5 629	0.770	1 569	5 230	450/65.3	450/72.4	450/79.4	400/77.4
		1 in 4	100	2 906	4 013	0.381	1 446	5 916	350/49.5	350/52.4	350/56.9	350/67.4
			150	3 159	4 016	0.547	1 446	5 916	400/56.9	400/61.6	400/66.7	350/67.4
			200	3 468	5 344	0.712	1 446	5 916	450/65.3	450/72.4	450/79.4	400/77.4
		1 in 5	100	2 993	4 107	0.364	1 347	6 364	350/49.5	400/61.6	350/56.9	300/58.8
			150	2 993	4 107	0.525	1 347	6 364	400/56.9	400/61.6	400/66.7	350/67.4
			200	3 463	5 227	0.686	1 347	6 364	450/65.3	450/72.4	450/79.4	400/77.4

Δ = Side sway (cm), I = Moment of inertia (cm^4).

TABLE 23 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 18 m — Type of Support : Fixed — No. of Bays : 3

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
4.50	6.00	1 in 3	100	3 301	7 317	0.226	3 160	6 711	350/49.5	400/ 61.6	350/ 56.9	300/58.8
			150	3 301	7 317	0.239	3 160	6 711	350/49.5	400/ 61.6	350/ 56.9	300/58.8
			200	3 301	7 317	0.280	3 160	6 711	400/56.9	400/ 61.6	350/ 56.9	350/67.4
		1 in 4	100	3 482	7 784	0.226	3 257	7 648	400/56.9	400/ 61.6	350/ 59.9	300/58.8
			150	3 482	7 784	0.226	3 257	7 648	400/56.9	400/ 61.6	350/ 56.9	300/58.8
			200	3 482	7 784	0.240	3 257	7 648	400/56.9	400/ 61.6	350/ 56.9	300/58.8
		1 in 5	100	3 588	8 212	0.215	3 528	8 179	400/56.9	400/ 61.6	350/ 56.9	300/58.8
			150	3 588	8 212	0.215	3 528	8 179	400/56.9	400/ 61.6	350/ 56.9	300/58.8
			200	3 588	8 212	0.215	3 528	8 179	400/56.9	400/ 61.6	350/ 56.9	300/58.8
	9.00	1 in 3	100	3 218	6 982	0.531	2 435	7 460	450/65.3	450/ 72.4	400/ 66.7	350/67.4
			150	3 218	6 982	0.705	2 435	7 460	450/65.3	450/ 72.4	450/ 79.4	400/77.4
			200	3 218	6 982	0.879	1 536	8 708	500/75.0	450/ 72.4	450/ 79.4	450/87.2
		1 in 4	100	3 377	7 533	0.459	2 327	8 639	500/75.0	450/ 72.4	400/ 66.7	350/67.4
			150	3 377	7 533	0.613	2 328	8 639	500/75.0	450/ 72.4	400/ 66.7	400/77.4
			200	3 377	7 533	0.766	2 328	8 639	500/75.0	450/ 72.4	450/ 79.4	400/77.4
		1 in 5	100	3 474	7 832	0.418	2 170	9 424	500/75.0	500/ 86.9	400/ 66.7	350/67.4
			150	3 474	7 832	0.563	2 170	9 424	500/75.0	500/ 86.9	400/ 66.7	350/72.4
			200	3 474	7 832	0.707	2 170	9 424	500/75.0	500/ 86.9	450/ 79.4	400/77.4
	12.00	1 in 3	100	3 135	6 664	1.120	1 893	8 355	600/99.5	550/103.7	450/ 79.4	450/87.2
			150	3 135	6 664	1.566	1 893	8 355	600/99.5	550/103.7	500/ 95.2	—
			200	1 111	9 273	2.0124	1 458	10 516	600/99.5	550/103.7	500/ 95.2	—
		1 in 4	100	3 289	7 015	1.0049	1 770	9 569	600/99.5	550/103.7	450/ 79.4	400/77.4
			150	3 289	7 015	1.417	1 770	9 569	600/99.5	550/103.7	500/ 95.2	450/87.2
			200	2 110	8 537	1.830	1 286	10 318	600/99.5	550/103.7	500/ 95.2	—
		1 in 5	100	3 386	7 204	1.947	1 665	10 370	600/99.5	550/103.7	450/ 79.4	400/77.4
			150	3 386	7 204	1.346	1 665	10 370	600/99.5	550/103.7	450/ 79.4	450/87.2
			200	2 406	8 814	1.746	1 665	10 370	600/99.5	550/103.7	500/ 95.2	—

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 24 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 18 m Type of Support : Fixed No. of Bays : 3

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
6.00	6.00	1 in 3	100	4 541	10 066	0.311	4 346	9 232	450/65.3	450/ 72.4	400/ 66.7	350/67.4
			150	4 541	10 066	0.329	4 346	9 232	450/65.3	450/ 72.4	400/ 66.7	350/67.4
			200	4 541	10 066	0.384	4 346	9 232	450/65.3	450/ 72.4	400/ 66.7	400/77.4
		1 in 4	100	4 778	10 682	0.311	4 469	10 496	450/65.3	450/ 72.4	400/ 66.7	350/67.4
			150	4 778	10 682	0.311	4 469	10 496	450/65.3	450/ 72.4	400/ 66.7	350/67.4
			200	4 778	10 682	0.329	4 469	10 496	450/65.3	450/ 72.4	400/ 66.7	350/67.4
		1 in 5	100	4 917	11 254	0.295	4 472	11 254	450/65.3	450/ 72.4	400/ 66.7	350/67.4
			150	4 917	11 254	0.295	4 472	11 254	450/65.3	450/ 72.4	400/ 66.7	350/67.4
			200	4 917	11 254	0.295	4 472	11 254	450/65.3	450/ 72.4	400/ 66.7	350/67.4
	9.00	1 in 3	100	4 427	9 604	0.724	3 350	10 262	550/86.3	500/ 86.9	450/ 79.4	400/77.4
			150	4 427	9 604	0.956	3 350	10 262	550/86.3	500/ 86.9	450/ 79.4	450/87.2
			200	4 427	9 604	1.188	2 125	11 847	550/86.3	500/ 86.9	500/ 95.2	—
		1 in 4	100	4 634	10 337	0.625	3 194	11 855	550/86.3	500/ 86.9	450/ 79.4	400/77.4
			150	4 634	10 337	0.829	3 194	11 855	550/86.3	500/ 86.9	450/ 79.4	400/82.2
			200	4 634	10 337	1.0341	3 194	11 855	550/86.3	500/ 86.9	500/ 95.2	450/87.2
		1 in 5	100	4 760	10 733	0.568	2 974	12 915	550/86.3	500/ 86.9	450/ 79.4	350/72.4
			150	4 760	10 733	0.761	2 974	12 915	550/86.3	500/ 86.9	450/ 79.4	400/77.4
			200	4 760	10 733	0.953	2 974	12 915	550/86.3	500/ 86.9	450/ 79.4	450/87.2
	12.00	1 in 3	100	4 313	9 167	1.513	2 604	11 493	600/99.5	550/103.7	500/ 95.2	450/87.2
			150	611	10 116	2.107	1 761	11 847	600/99.5	550/103.7	550/112.5	—
			200	1 382	12 532	2.702	2 004	14 286	600/99.5	600/122.6	550/112.5	—
		1 in 4	100	4 514	9 626	1.355	2 428	13 131	600/99.5	550/103.7	500/ 95.2	450/87.2
			150	4 514	9 626	1.905	2 428	13 131	600/99.5	550/103.7	500/ 95.2	—
			200	5 353	10 143	2.455	1 765	14 031	600/99.5	550/103.7	550/112.5	—
		1 in 5	100	4 640	9 872	1.275	2 281	14 211	600/99.5	550/103.7	500/ 95.2	450/87.2
			150	4 640	9 872	1.808	2 281	14 211	600/99.5	550/103.7	500/ 95.2	—
			200	3 114	11 612	2.340	2 282	14 211	600/99.5	550/103.7	550/112.5	—

Δ = Side sway (cm), I = Moment of inertia (cm^4).

TABLE 25 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 9 m — Type of Support : Fixed — No. of Bays : 4

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
4.50	4.50	1 in 3	100	1 568	1 747	0.0287	1 306	1 813	225/23.5	200/25.4	200/28.8	200/37.3
			150	1 568	1 747	0.0369	1 306	1 813	250/27.9	225/31.2	200/28.8	200/37.3
			200	1 568	1 747	0.0452	1 306	1 813	250/27.9	225/31.2	225/33.9	200/37.3
		1 in 4	100	1 649	1 892	0.0246	1 264	2 123	250/27.9	200/25.4	200/28.8	200/37.3
			150	1 649	1 892	0.0318	1 264	2 123	250/27.9	200/25.4	200/28.8	200/37.3
			200	1 649	1 892	0.0390	1 264	2 123	250/27.9	225/31.2	225/33.9	200/37.3
		1 in 5	100	1 697	1 966	0.0226	1 205	2 325	250/27.9	200/25.4	200/28.8	150/34.6
			150	1 697	1 966	0.0293	1 205	2 325	250/27.9	200/25.4	200/28.8	200/37.3
			200	1 697	1 966	0.0359	1 205	2 325	250/27.9	225/31.2	200/28.8	200/37.3
	6.00	1 in 3	100	1 526	1 674	0.0544	1 009	2 048	250/27.9	225/31.2	225/33.9	200/37.3
			150	1 526	1 674	0.0739	1 009	2 048	275/33.0	250/37.3	225/33.9	225/43.1
			200	1 526	1 674	0.0934	1 009	2 048	275/33.0	250/37.3	250/40.9	225/43.1
		1 in 4	100	1 603	1 761	0.0485	931	2 316	250/27.9	225/31.2	200/28.8	200/37.3
			150	1 603	1 761	0.0657	931	2 316	250/27.9	225/31.2	225/33.9	200/37.3
			200	1 603	1 761	0.0842	931	2 316	275/33.0	250/37.3	250/40.9	225/43.1
		1 in 5	100	1 649	1 803	0.0446	863	2 485	250/27.9	225/31.2	200/28.8	200/37.3
			150	1 649	1 803	0.0616	863	2 485	250/27.9	225/31.2	225/33.9	200/37.3
			200	1 649	1 803	0.07903	863	2 485	275/33.0	250/37.3	250/40.9	225/43.1

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 26 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 9 m | Type of Support : Fixed | No. of Bays : 3

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection					Alternate Design Sections for Beam and Column			
				Column			Beam					
				Axial	Moment	$\Delta I/10^5$	Axial	Moment	ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
6.00	4.50	1 in 3	100	2 160	2 407	0.0395	1 798	2 498	250/27.9	225/31.2	225/33.9	200/37.3
			150	2 160	2 407	0.0503	1 798	2 498	250/27.9	250/37.3	225/33.9	200/37.3
			200	2 160	2 407	0.0611	1 798	2 498	275/33.0	250/37.3	250/40.9	225/43.1
		1 in 4	100	2 266	2 600	0.0339	1 736	2 917	250/27.9	225/31.2	200/28.8	200/37.3
			150	2 266	2 600	0.0436	1 736	2 917	250/27.9	225/31.2	225/33.9	200/37.3
			200	2 266	2 600	0.0534	1 736	2 917	250/27.9	250/37.3	225/33.9	200/40.0
		1 in 5	100	2 328	2 697	0.0308	1 653	3 190	250/27.9	225/31.2	200/28.8	200/37.3
			150	2 328	2 697	0.0395	1 653	3 190	250/27.9	225/31.2	225/33.9	200/37.3
			200	2 328	2 697	0.0488	1 653	3 190	250/27.9	225/31.2	225/33.9	200/37.3
	6.00	1 in 3	100	2 102	2 306	0.0744	1 390	2 820	275/33.0	250/37.3	225/33.9	225/43.1
			150	2 102	2 306	0.0996	1 390	2 820	275/33.0	300/44.2	250/40.9	225/43.1
			200	2 102	2 306	0.1258	1 390	2 820	300/37.7	300/44.2	300/48.1	250/51.0
		1 in 4	100	2 201	2 419	0.0657	1 279	3 182	275/33.0	250/37.3	225/33.9	200/37.3
			150	2 201	2 419	0.0888	1 279	3 182	275/33.0	250/37.3	250/40.9	225/43.1
			200	2 201	2 419	0.113	1 279	3 182	300/37.7	300/44.2	250/40.9	250/51.0
		1 in 5	100	2 263	2 473	0.0604	1 184	3 409	275/33.0	250/37.3	225/33.9	200/37.3
			150	2 263	2 473	0.0831	1 184	3 409	275/33.0	250/37.3	250/40.9	225/43.1
			200	2 263	2 473	0.107	1 184	3 409	300/37.3	300/44.2	250/40.9	250/51.0

Δ = Side sway (cm), I = Moment of inertia (cm).

TABLE 27 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 12 m — Type of Support : Fixed — No. of Bays : 4

Spacing of Frame (m)	Column Height (m)	Roof Slope	Basic Wind Pressure (kg/m²)	Design Forces and Sway Deflection: Column Axial (kg)	Column Moment (kg. m)	Column $\Delta I/10^5$ (cm⁵)	Beam Axial (kg)	Beam Moment (kg. m)	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
4.50	4.50	1 in 3	100	2 161	3 338	0.0580	1 970	3 078	275/33.0	200/37.3	250/40.9	225/43.1
			150	2 161	3 338	0.0647	1 970	3 078	275/33.0	250/37.3	250/40.9	225/43.1
			200	2 161	3 338	0.0770	1 970	3 078	275/33.0	300/44.2	250/40.9	225/46.8
		1 in 4	100	2 282	3 534	0.0580	2 323	3 360	275/33.0	250/37.3	250/40.9	225/43.1
			150	2 282	3 534	0.0580	2 323	3 360	275/33.0	250/37.3	250/40.9	225/43.1
			200	2 282	3 534	0.0672	2 323	3 360	275/33.0	250/37.3	250/40.9	225/43.1
		1 in 5	100	2 351	3 700	0.0549	2 305	3 788	275/33.0	250/37.3	225/33.9	225/43.1
			150	2 351	3 700	0.0549	2 305	3 788	275/33.0	250/37.3	225/33.9	225/43.1
			200	2 351	3 700	0.0611	2 305	3 788	275/33.0	250/37.3	250/40.9	225/43.1
	6.00	1 in 3	100	2 121	3 155	0.0924	1 772	3 265	300/37.7	250/37.3	250/40.9	225/43.1
			150	2 121	3 155	0.118	1 772	3 265	300/37.7	300/44.2	300/48.1	250/51.0
			200	2 121	3 155	0.144	1 772	3 265	325/43.1	300/44.2	300/48.1	250/51.0
		1 in 4	100	2 229	3 414	0.0801	1 715	3 821	300/37.7	250/37.3	250/40.9	225/43.1
			150	2 229	3 414	0.102	1 715	3 821	300/37.7	300/44.2	250/40.9	225/46.8
			200	2 229	3 414	0.125	1 715	3 821	300/37.7	300/44.2	300/48.1	250/51.0
		1 in 5	100	2 291	3 546	0.0724	1 635	4 183	300/37.7	250/37.3	225/33.9	225/43.1
			150	2 291	3 546	0.0929	1 635	4 183	300/37.7	250/37.3	250/40.9	225/43.1
			200	2 291	3 546	0.114	1 635	4 183	300/37.7	300/44.2	250/40.9	250/51.0
	9.00	1 in 3	100	2 036	2 917	0.295	1 232	3 835	350/49.5	350/52.4	350/56.9	300/58.8
			150	388	3 784	0.415	1 232	3 835	400/56.9	400/61.6	350/56.9	350/67.4
			200	770	4 754	0.534	795	4 813	400/56.9	400/61.6	400/66.7	350/67.4
		1 in 4	100	2 137	3 040	0.267	1 119	4 287	325/43.1	350/52.4	300/48.1	300/58.8
			150	2 137	3 040	0.379	1 119	4 287	350/49.5	350/52.4	350/56.9	350/67.4
			200	2 448	3 655	0.491	1 122	4 718	400/56.9	400/61.6	400/66.7	350/67.4
		1 in 5	100	2 200	3 099	0.253	1 028	4 571	325/43.1	350/52.4	300/48.1	300/58.8
			150	2 200	3 099	0.361	1 028	4 571	350/49.5	350/52.4	350/56.9	300/58.8
			200	2 437	3 546	0.470	1 071	4 771	400/56.9	400/61.6	400/66.7	350/67.4

Δ = Side sway (cm), I = Moment of inertia (cm⁴)

TABLE 28 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 12 m — Type of Support : Fixed — No. of Bays : 4

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column			Beam		Alternate Design Sections for Beam and Column			
				Axial	Moment	$\Delta I/10^5$	Axial	Moment	ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
6.00	4.50	1 in 3	100	2 975	4 596	0.0795	3 099	3 786	300/37.7	300/44.2	250/40.9	250/51.0
			150	2 975	4 596	0.0888	3 099	3 786	300/37.7	300/44.2	300/48.1	250/51.0
			200	2 975	4 596	0.105	3 099	3 786	300/37.7	300/44.2	300/48.1	250/51.0
		1 in 4	100	3 134	4 853	0.0795	3 190	4 614	300/37.7	300/44.2	250/40.9	225/46.8
			150	3 134	4 853	0.0795	3 190	4 614	300/37.7	300/44.2	250/40.9	225/46.8
			200	3 134	4 853	0.0919	3 190	4 614	300/37.7	300/44.2	300/48.1	250/51.0
		1 in 5	100	3 224	5 074	0.0754	3 161	5 194	300/37.7	300/44.2	250/40.9	225/43.1
			150	3 224	5 074	0.0754	3 161	5 194	300/37.7	300/44.2	250/40.9	225/43.1
			200	3 224	5 074	0.0831	3 161	5 194	300/37.7	300/44.2	250/40.9	250/51.0
	6.00	1 in 3	100	2 921	4 344	0.126	2 440	4 496	325/43.1	300/44.2	300/48.1	250/51.0
			150	2 921	4 344	0.160	2 440	4 496	325/43.1	300/44.2	300/48.1	300/58.8
			200	2 921	4 344	0.195	2 440	4 496	350/49.5	350/52.4	350/56.9	300/58.8
		1 in 4	100	3 060	4 689	0.109	2 355	5 247	325/43.1	300/44.2	250/40.9	250/51.0
			150	3 060	4 689	0.140	2 355	5 247	325/43.1	300/44.2	300/48.1	250/51.0
			200	3 060	4 689	0.170	2 355	5 247	325/43.1	350/52.4	300/48.1	300/58.8
		1 in 5	100	3 142	4 863	0.0985	2 242	5 736	325/43.1	300/44.2	250/40.9	225/43.1
			150	3 142	4 863	0.127	2 242	5 736	325/43.1	300/44.2	300/48.1	250/51.0
			200	3 142	4 863	0.155	2 242	5 736	325/43.1	300/44.2	300/48.1	300/58.8
	9.00	1 in 3	100	2 804	4 017	0.398	1 697	5 280	400/56.9	400/61.6	350/56.9	350/67.4
			150	450	5 121	0.550	989	5 416	400/56.9	400/61.6	400/66.7	350/72.4
			200	3 432	5 194	0.717	1 099	6 542	450/65.3	450/72.4	450/79.4	400/77.4
		1 in 4	100	2 935	4 174	0.360	1 537	5 887	350/49.5	400/61.6	350/56.9	300/58.8
			150	2 935	4 174	0.509	1 537	5 887	400/56.9	400/61.6	400/66.7	350/67.4
			200	3 402	4 884	0.658	1 530	6 403	450/65.3	450/72.4	400/66.7	400/77.4
		1 in 5	100	3 016	4 250	0.340	1 409	6 268	350/49.5	400/61.6	350/56.9	300/58.8
			150	3 016	4 250	0.485	1 409	6 268	400/56.9	400/61.6	400/66.7	450/67.4
			200	3 386	4 736	0.629	1 457	6 476	450/65.3	450/72.4	400/66.7	400/77.4

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 29 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 9 m | Type of Support : Hinged | No. of Bays : 1

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg m)	(cm⁵)	(kg)	(kg. m)				
4.50	4.50	1 in 3	100	1 550	1 649	0.129	789	1 649	325/43.1	350/52.4	300/48.1	300/58.8
			150	1 550	1 695	0.195	789	1 695	400/56.9	350/52.4	350/56.9	350/67.4
			200	1 001	2 466	0.117	611	2 466	400/56.9	400/61.6	400/66.7	350/67.4
		1 in 4	100	1 653	1 779	0.179	744	1 779	325/43.1	300/44.2	300/48.1	300/58.8
			150	1 653	1 779	0.240	744	1 779	350/49.5	350/52.4	350/56.9	300/58.8
			200	1 146	2 516	0.113	585	2 516	400/56.9	400/61.6	400/66.7	350/67.4
		1 in 5	100	1 719	1 863	0.172	709	1 863	325/43.1	300/44.2	300/48.1	250/54.7
			150	1 719	1 863	0.232	709	1 863	350/49.5	350/52.4	350/56.9	300/58.8
			200	1 246	2 586	0.232	567	2 586	400/56.9	400/61.6	400/66.7	350/67.4
	6.00	1 in 3	100	718	2 082	0.353	376	2 082	400/56.9	400/61.6	400/66.7	350/67.4
			150	854	2 817	0.529	436	2 824	450/65.3	450/72.4	450/79.4	400/77.4
			200	1 338	3 968	0.712	745	3 969	500/75.0	500/86.9	500/95.2	450/87.2
		1 in 4	100	653	1 929	0.330	291	1 929	400/56.9	400/61.6	400/66.7	350/67.4
			150	958	2 817	0.496	454	2 817	450/65.3	450/72.4	450/79.4	400/77.4
			200	1 473	3 966	0.667	681	3 966	500/75.0	500/86.9	450/79.4	450/87.2
		1 in 5	100	1 719	1 752	0.322	320	1 853	400/56.9	400/61.6	400/66.7	350/67.4
			150	1 031	2 855	0.483	429	2 855	450/65.3	450/72.4	450/79.4	400/77.4
			200	1 569	4 014	0.649	640	4 014	500/75.0	500/86.9	450/79.4	450/87.2

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 30 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 9 m | Type of Support : Hinged | No. of Bays : 1

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
6.00	4.50	1 in 3	100	2 136	2 271	0.173	1 087	2 271	350/49.5	350/ 52.4	350/56.9	300/58.8
			150	2 136	2 271	0.259	1 087	2 271	400/56.9	400/ 61.6	400/66.7	350/67.4
			200	1 284	3 233	0.349	789	3 233	450/65.3	450/ 72.4	450/79.4	400/77.4
		1 in 4	100	2 271	2 444	0.157	1 023	2 444	350/49.5	350/ 52.4	350/56.9	300/58.8
			150	2 271	2 444	0.237	1 023	2 444	400/56.9	400/ 61.6	400/66.7	350/67.4
			200	1 478	3 301	0.320	758	3 301	450/65.3	450/ 72.4	400/66.7	400/77.4
		1 in 5	100	2 358	2 556	0.151	973	2 556	350/49.5	350/ 52.4	350/56.9	300/58.8
			150	2 358	2 556	0.228	973	2 556	400/56.9	400/ 61.6	400/66.7	350/67.4
			200	1 612	3 394	0.308	736	3 394	450/65.3	450/ 72.4	400/66.7	400/77.4
	6.00	1 in 3	100	1 008	2 828	0.472	524	2 828	450/65.3	450/ 72.4	450/79.4	400/77.4
			150	1 104	3 817	0.705	604	3 817	500/75.0	500/ 86.9	500/95.2	450/87.2
			200	1 733	5 240	0.947	970	5 240	550/86.3	550/103.7	500/95.2	—
		1 in 4	100	2 271	2 310	0.440	869	2 310	450/65.3	450/ 72.4	400/66.7	400/77.4
			150	1 227	3 705	0.660	586	3 705	500/75.0	500/ 86.9	450/79.4	450/87.2
			200	1 914	5 237	0.887	888	5 237	550/86.3	550/103.7	500/95.2	—
		1 in 5	100	2 358	2 403	0.428	439	2 542	450/65.3	450/ 72.4	400/66.7	400/77.4
			150	1 326	3 756	0.643	556	3 756	500/75.0	500/ 86.9	450/79.4	450/87.2
			200	2 042	5 302	0.864	836	5 302	550/86.3	500/ 86.9	500/95.2	—

Δ = Side sway (cm), I = Moment of inertia (cm^4).

TABLE 31 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 12 m | Type of Support : Hinged | No. of Bays : 1

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
4.50	4.50	1 in 3	100	2 096	3 033	0.158	1 236	3 033	350/49.5	350/ 52.4	350/ 56.9	300/58.8
			150	2 096	3 033	0.234	1 236	3 033	400/56.9	400/ 61.6	400/ 66.7	350/67.4
			200	2 096	3 033	0.320	1 236	3 033	450/65.3	450/ 72.4	400/ 66.7	400/77.4
		1 in 4	100	2 232	3 309	0.135	1 201	3 309	325/43.1	350/ 52.4	300/ 48.1	300/58.8
			150	2 232	3 309	0.209	1 201	3 309	400/56.9	400/ 61.6	350/ 56.9	350/67.4
			200	2 232	3 309	0.285	1 201	3 309	450/65.3	400/ 61.6	400/ 66.7	350/72.4
		1 in 5	100	2 320	3 488	0.128	1 169	3 488	325/43.1	350/ 52.4	300/ 48.1	300/58.8
			150	2 320	3 488	0.198	1 169	3 488	400/56.9	350/ 52.4	350/ 56.9	350/67.4
			200	2 320	3 488	0.269	1 169	3 488	400/56.9	400/ 61.6	400/ 66.7	350/67.4
	6.00	1 in 3	100	2 096	2 972	0.410	1 066	2 972	450/65.3	450/ 72.4	400/ 66.7	400/77.4
			150	2 096	2 972	0.613	1 066	2 972	500/75.0	500/ 86.9	450/ 79.4	450/87.2
			200	1 313	4 354	0.830	804	4 354	550/86.3	500/ 86.9	500/ 95.2	—
		1 in 4	100	2 232	3 204	0.371	1 005	3 204	400/56.9	400/ 61.6	400/ 66.7	350/67.4
			150	2 232	3 204	0.562	1 005	3 204	500/75.0	450/ 72.4	450/ 79.4	450/87.2
			200	1 507	4 445	0.759	771	4 445	550/86.3	500/ 86.9	500/ 95.2	450/87.2
		1 in 5	100	2 320	3 354	0.357	958	3 354	400/56.9	400/ 61.6	400/ 66.7	350/67.4
			150	2 320	3 354	0.541	958	3 354	500/75.0	450/ 72.4	450/ 79.4	400/77.4
			200	1 640	4 568	0.731	748	4 568	500/75.0	500/ 86.9	500/ 95.2	450/87.2
	9.00	1 in 3	100	1 225	5 712	2.263	937	7 586	—	600/122.6	600/133.7	—
			150	2 035	8 663	3.410	1 571	11 894	—	—	—	—
			200	2 975	11 894	4.557	2 205	16 203	—	—	—	—
		1 in 4	100	1 217	5 405	2.140	845	7 542	—	600/122.6	560/112.5	—
			150	2 208	8 612	3.221	1 405	11 817	—	—	600/145.1	—
			200	3 200	11 817	4.302	1 966	16 093	—	—	—	—
		1 in 5	100	1 303	5 454	2.094	787	7 605	600/99.5	600/122.6	550/112.5	—
			150	2 334	8 680	3.149	1 302	11 906	—	—	600/145.1	—
			200	3 365	11 906	4.205	1 816	16 077	—	—	—	—

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 32 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 12 m | Type of Support : Hinged | No. of Bays : 1

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
6.00	4.50	1 in 3	100	2 885	4 176	0.211	1 702	4 176	400/56.9	400/ 61.6	350/ 56.9	350/67.4
			150	2 885	4 176	0.312	1 702	4 176	450/65.3	450/ 72.4	400/ 66.7	400/77.4
			200	2 885	4 176	0.427	1 702	4 176	500/75.0	450/ 72.4	450/ 79.4	450/87.2
		1 in 4	100	3 065	4 544	0.181	1 649	4 544	350/49.5	350/ 52.4	350/ 56.9	300/58.8
			150	3 065	4 544	0.277	1 649	4 544	400/56.9	400/ 61.6	400/ 66.7	350/67.4
			200	3 065	4 544	0.378	1 649	4 544	450/65.3	450/ 72.4	450/ 79.4	400/77.4
		1 in 5	100	3 181	4 783	0.170	1 604	4 783	350/49.5	350/ 52.4	350/ 56.9	300/58.8
			150	3 181	4 783	0.262	1 604	4 783	400/56.9	400/ 61.6	400/ 66.7	350/67.4
			200	3 181	4 783	0.357	1 604	4 783	450/65.3	450/ 72.4	450/ 79.4	400/77.4
	6.00	1 in 3	100	2 885	4 092	0.549	1 468	4 092	500/75.0	450/ 72.4	450/ 79.4	400/82.2
			150	2 885	4 092	0.816	1 468	4 092	550/86.3	500/ 86.9	500/ 95.2	—
			200	1 683	5 709	1.104	1 468	5 709	600/99.5	550/103.7	550/112.5	—
		1 in 4	100	3 065	4 400	0.495	1 380	4 400	450/65.3	450/ 72.4	450/ 79.4	400/77.4
			150	3 065	4 400	0.748	1 380	4 400	550/86.3	500/ 86.9	500/ 95.2	450/87.2
			200	1 943	5 831	1.010	998	5 831	550/86.3	550/103.7	500/ 95.2	—
		1 in 5	100	3 181	4 599	0.476	1 313	4 599	450/65.3	450/ 72.4	450/ 79.4	400/77.4
			150	3 181	4 599	0.721	1 313	4 599	500/75.0	500/ 86.9	500/ 95.2	450/87.2
			200	2 121	5 996	0.972	970	5 996	550/86.3	550/103.7	500/ 95.2	—
	9.00	1 in 3	100	1 701	7 707	3.0150	1 220	10 024	—	—	600/133.7	—
			150	2 646	11 461	4.543	2 066	15 769	—	—	—	—
			200	3 898	15 769	6.0737	2 911	21 514	—	—	—	—
		1 in 4	100	1 548	7 202	2.851	1 103	9 968	—	—	600/133.7	—
			150	2 877	11 394	4.292	1 850	15 669	—	—	—	—
			200	4 199	15 669	5.734	2 597	21 369	—	—	—	—
		1 in 5	100	1 672	7 185	2.789	1 028	10 053	—	—	600/133.7	—
			150	3 046	11 487	4.197	1 715	15 788	—	—	—	—
			200	4 420	15 788	5.605	2 401	21 523	—	—	—	—

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 33 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 18 m — Type of Support : Hinged — No. of Bays : 1

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column			Beam		Alternate Design Sections for Beam and Column			
				Axial	Moment	$\Delta I/10^5$	Axial	Moment	ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
4.5	6.00	1 in 3	100	3 229	7 017	0.552	2 028	7 017	500/75.0	450/ 72.4	450/ 79.4	400/82.2
			150	3 229	7 017	0.811	2 028	7 017	550/86.3	500/ 86.9	500/ 95.2	—
			200	3 229	7 017	1.118	2 028	7 017	600/99.5	550/103.7	550/112.5	—
		1 in 4	100	3 431	7 683	0.458	1 991	7 683	450/65.3	450/ 72.4	450/ 79.4	400/77.4
			150	3 431	7 683	0.711	1 991	7 683	500/75.0	500/ 86.9	500/ 95.2	450/87.2
			200	3 431	7 683	0.977	1 991	7 683	550/86.3	550/103.7	500/ 95.2	—
		1 in 5	100	3 562	8 116	0.426	1 955	8 116	450/65.3	450/ 72.4	400/ 66.7	400/77.4
			150	3 562	8 116	0.667	1 955	8 116	500/75.0	500/ 86.9	450/ 79.4	450/87.2
			200	3 562	8 116	0.914	1 955	8 116	550/86.3	550/103.7	500/ 95.2	—
	9.00	1 in 3	100	3 229	6 872	2.753	974	8 296	—	—	600/133.7	—
			150	1 906	9 663	4.193	1 776	13 763	—	—	—	—
			200	2 954	13 763	5.623	2 578	19 230	—	—	—	—
		1 in 4	100	3 431	7 392	2.526	943	8 482	—	600/122.6	600/133.7	—
			150	2 199	9 868	3.837	1 687	14 028	—	—	—	—
			200	3 335	14 028	5.148	2 432	19 574	—	—	—	—
		1 in 5	100	3 562	7 728	2.435	920	8 730	—	600/122.6	600/133.7	—
			150	2 399	10 147	3.692	1 627	14 396	—	—	—	—
			200	3 598	14 396	7.519	2 335	20 061	—	—	—	—
	12.00	1 in 3	100	1 629	10 528	7.519	1 225	13 663	—	—	—	—
			150	2 581	15 685	11.353	2 113	21 752	—	—	—	—
			200	3 854	21 752	15.188	3 001	29 841	—	—	—	—
		1 in 4	100	1 463	9 724	7.056	1 127	13 661	—	—	—	—
			150	2 852	15 676	10.641	1 922	21 724	—	—	—	—
			200	4 206	21 724	14.226	2 717	29 787	—	—	—	—
		1 in 5	100	1 630	9 767	6.879	1 063	13 837	—	—	—	—
			150	3 045	15 872	10.366	1 800	21 978	—	—	—	—
			200	4 459	21 978	13.851	2 538	30 118	—	—	—	—

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 34 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 18 m | Type of Support : Hinged | No. of Bays : 1

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
6.00	6.00	1 in 3	100	4 442	9 653	0.744	2 790	9 653	500/75.0	500/ 86.9	500/ 95.2	450/87.2
			150	4 442	9 653	1.0694	2 790	9 653	600/99.5	550/103.7	550/112.5	—
			200	4 442	9 653	1.482	2 790	9 653	—	600/122.6	600/133.7	—
		1 in 4	100	4 709	10 543	0.617	2 732	10 543	500/75.0	500/ 86.9	450/ 79.4	450/87.2
			150	4 709	10 543	0.941	2 732	10 543	550/86.3	550/103.7	500/ 95.2	—
			200	4 709	10 543	1.297	2 732	10 543	600/99.5	600/122.6	550/112.5	—
		1 in 5	100	4 882	11 123	0.563	2 679	11 123	500/75.0	500/ 86.9	450/ 79.4	450/87.2
			150	4 882	11 123	0.884	2 679	11 123	550/86.3	550/103.7	500/ 95.2	—
			200	4 882	11 123	1.213	2 679	11 123	600/99.5	550/103.7	550/112.5	—
	9.00	1 in 3	100	4 442	9 453	3.663	1 246	10 844	—	—	—	—
			150	2 439	12 666	5.579	2 316	18 133	—	—	—	—
			200	3 837	18 133	7.499	3 385	25 422	—	—	—	—
		1 in 4	100	4 709	10 144	3.360	1 212	11 093	—	—	—	—
			150	2 831	12 992	5.108	2 205	18 488	—	—	—	—
			200	4 347	18 488	6.856	3 197	25 883	—	—	—	—
		1 in 5	100	4 882	10 591	3.240	1 186	11 425	—	—	600/145.1	—
			150	3 099	13 314	4.916	2 129	18 979	—	—	—	—
			200	4 698	18 979	6.592	3 072	26 533	—	—	—	—
	12.00	1 in 3	100	2 274	14 246	10.0129	1 588	18 010	—	—	—	—
			150	3 338	20 706	15.125	2 772	28 795	—	—	—	—
			200	5 036	28 795	20.238	3 956	39 580	—	—	—	—
		1 in 4	100	2 051	13 169	9.399	1 464	18 010	—	—	—	—
			150	3 702	20 698	14.179	2 524	28 761	—	—	—	—
			200	5 508	28 761	18.959	3 584	39 512	—	—	—	—
		1 in 5	100	2 075	12 820	9.165	1 384	18 247	—	—	—	—
			150	3 961	20 961	13.813	2 367	29 101	—	—	—	—
			200	5 847	29 101	18.461	3 350	39 955	—	—	—	—

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 35 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 24 m   Type of Support : Hinged   No. of Bays : 1

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column			Design Forces and Sway Deflection: Beam		Alternate Design Sections for Beam and Column			
				Axial	Moment	$\Delta I/10^5$	Axial	Moment	ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
4.50	9.00	1 in 3	100	4 419	12 794	3.292	2 606	12 794	—	—	600/145.1	—
			150	4 419	12 794	5.108	2 125	16 263	—	—	—	—
			200	3 176	16 263	6.914	3 175	23 361	—	—	—	—
		1 in 4	100	4 686	13 899	2.931	2 521	13 899	—	—	600/133.7	—
			150	4 686	13 899	4.524	2 127	17 141	—	—	—	—
			200	3 714	17 141	6.128	3 140	24 535	—	—	—	—
		1 in 5	100	4 860	14 617	2.782	2 450	14 617	—	—	600/133.7	—
			150	4 860	14 617	4.280	2 119	17 967	—	—	—	—
			200	4 074	17 967	5.777	3 108	25 641	—	—	—	—
	12.00	1 in 3	100	4 419	12 537	8.687	1 255	14 505	—	—	—	—
			150	2 456	16 934	13.232	2 324	24 222	—	—	—	—
			200	3 854	24 222	17.778	3 393	33 939	—	—	—	—
		1 in 4	100	4 686	13 458	7.695	1 220	14 837	—	—	—	—
			150	2 848	17 301	12.107	2 212	24 695	—	—	—	—
			200	4 364	24 695	16.259	3 204	34 553	—	—	—	—
		1 in 5	100	4 860	14 054	7.678	1 192	15 279	—	—	—	—
			150	3 116	17 797	11.650	2 135	25 349	—	—	—	—
			200	4 714	25 350	15.622	3 078	35 420	—	—	—	—

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 36 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 24 m — Type of Support : Hinged — No. of Bays : 1

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
6.00	9.00	1 in 3	100	6 074	17 586	4.418	3 583	17 586	—	—	—	—
			150	6 074	17 586	6.775	2 753	21 289	—	—	—	—
			200	4 098	21 289	9.197	4 153	30 753	—	—	—	—
		1 in 4	100	6 427	19 061	3.887	3 457	19 061	—	—	—	—
			150	6 427	19 061	6.0215	2 763	22 459	—	—	—	—
			200	4 818	22 459	8.145	4 115	32 317	—	—	—	—
		1 in 5	100	6 656	20 019	3.685	3 356	20 019	—	—	—	—
			150	6 656	20 019	5.682	2 759	23 558	—	—	—	—
			200	5 300	23 558	7.689	4 078	33 790	—	—	—	—
	12.00	1 in 3	100	6 074	17 233	11.607	1 405	19 230	—	—	—	—
			150	3 138	22 192	17.608	3 029	31 908	—	—	—	—
			200	5 002	31 909	23.672	4 455	44 865	—	—	—	—
		1 in 4	100	6 427	18 456	10.599	1 566	19 399	—	—	—	—
			150	3 664	22 685	16.121	2 889	32 543	—	—	—	—
			200	5 684	32 543	21.643	4 212	45 687	—	—	—	—
		1 in 5	100	6 656	19 249	10.227	1 535	19 990	—	—	—	—
			150	4 022	23 347	15.516	2 793	33 417	—	—	—	—
			200	6 154	33 417	20.815	4 050	46 844	—	—	—	—

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 37 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 30 m | Type of Support : Hinged | No. of Bays : 1

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
4.50	9.00	1 in 3	100	5 666	20 445	3.961	3 768	20 445	—	—	—	—
			150	5 666	20 445	6.170	3 768	20 445	—	—	—	—
			200	5 666	20 445	8.464	3 898	28 348	—	—	—	—
		1 in 4	100	5 997	22 421	3.356	3 726	22 421	—	—	—	—
			150	5 997	22 421	5.331	3 726	22 421	—	—	—	—
			200	5 997	22 421	7.296	4 009	30 727	—	—	—	—
		1 in 5	100	6 212	23 714	3.133	3 680	23 714	—	—	600/145.1	—
			150	6 212	23 714	4.938	3 680	23 714	—	—	—	—
			200	6 212	23 714	6.744	4 067	32 712	—	—	—	—
	12.00	1 in 3	100	5 666	20 465	10.0039	3 231	20 465	—	—	—	—
			150	5 666	20 465	15.325	2 630	27 237	—	—	—	—
			200	4 014	27 237	20.730	3 940	39 060	—	—	—	—
		1 in 4	100	5 997	22 125	8.900	3 098	22 125	—	—	—	—
			150	5 997	22 125	13.700	2 608	28 481	—	—	—	—
			200	4 682	28 481	18.500	3 861	40 715	—	—	—	—
		1 in 5	100	6 212	23 201	8.475	2 992	23 201	—	—	—	—
			150	6 212	23 201	13.0093	2 584	29 715	—	—	—	—
			200	5 131	29 715	17.544	3 799	42 364	—	—	—	—

Δ = Side sway (cm), I = Moment of inertia (cm^4).

TABLE 38 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 30 m | Type of Support : Hinged | No. of Bays : 1

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
6.00	9.00	1 in 3	100	7 782	28 082	5.331	5 175	28 082	—	—	—	—
			150	7 782	28 082	0.177	5 175	28 082	—	—	—	—
			200	7 782	28 082	11.236	5 084	37 181	—	—	—	—
		1 in 4	100	8 219	30 727	4.439	5 106	30 727	—	—	—	—
			150	8 219	30 727	7.0622	5 106	30 727	—	—	—	—
			200	8 219	30 727	9.685	5 242	40 346	—	—	—	—
		1 in 5	100	8 503	32 460	4.131	5 037	32 460	—	—	—	—
			150	8 503	32 460	6.542	5 037	32 460	—	—	—	—
			200	8 503	32 460	8.953	5 325	42 985	—	—	—	—
	12.00	1 in 3	100	7 782	28 110	13.402	4 437	28 110	—	—	—	—
			150	7 782	28 110	20.358	3 409	35 700	—	—	—	—
			200	5 181	35 700	27.569	5 156	51 463	—	—	—	—
		1 in 4	100	8 219	30 321	11.809	4 245	30 321	—	—	—	—
			150	8 219	30 321	18.213	3 391	37 359	—	—	—	—
			200	6 075	37 359	24.617	5 062	53 671	—	—	—	—
		1 in 5	100	8 503	31 758	11.257	4 096	31 758	—	—	—	—
			150	8 503	31 758	17.300	3 366	39 003	—	—	—	—
			200	6 676	39 003	23.342	4 986	55 869	—	—	—	—

Δ = Side sway (cm), I = Moment of inertia (cm^4).

TABLE 39 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 9 m　　Type of Support : Hinged　　No. of Bays : 2

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column			Beam		Alternate Design Sections for Beam and Column			
				Axial	Moment	$\Delta I/10^5$	Axial	Moment	ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
4.50	4.50	1 in 3	100	1 462	1 516	0.0981	789	2 311	300/37.7	300/44.2	300/48.1	250/51.0
			150	1 462	1 516	0.142	789	2 311	325/43.1	350/52.4	300/48.1	300/58.8
			200	515	1 734	0.185	789	2 311	350/49.5	350/52.4	350/56.9	300/63.0
		1 in 4	100	1 543	1 592	0.0886	731	2 581	300/37.7	300/44.2	300/48.1	250/51.0
			150	1 543	1 592	0.128	731	2 581	325/43.1	350/52.4	300/48.1	300/58.8
			200	1 543	1 592	0.169	731	2 581	350/49.5	350/52.4	350/56.9	300/58.8
		1 in 5	100	1 594	1 637	0.0845	685	2 758	300/37.7	300/44.2	250/40.9	250/51.0
			150	1 594	1 637	0.123	685	2 758	325/43.1	300/44.2	300/48.1	300/58.8
			200	1 594	1 637	0.164	685	2 758	350/49.5	350/52.4	350/56.9	300/58.8
	6.00	1 in 3	100	1 365	1 742	0.251	697	2 511	350/49.5	350/52.4	350/56.9	350/67.4
			150	1 427	2 603	0.369	697	2 511	400/56.9	400/61.6	400/66.7	350/67.4
			200	124	3 487	0.491	663	2 637	450/65.3	450/72.4	450/79.4	400/77.4
		1 in 4	100	1 323	1 635	0.234	626	2 766	350/49.5	350/52.4	350/56.9	300/58.8
			150	1 374	2 441	0.346	626	2 766	400/56.9	400/61.6	400/66.7	350/67.4
			200	42	3 270	0.459	626	2 766	450/65.3	450/72.4	450/79.4	400/77.4
		1 in 5	100	1 300	1 591	0.228	573	2 930	350/49.5	350/52.4	350/56.9	300/58.8
			150	1 343	2 376	0.337	573	2 930	400/56.9	400/61.6	400/66.7	350/67.4
			200	8	3 182	0.450	573	2 930	450/65.3	450/72.4	400/66.7	400/77.4

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 40 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 9 m | Type of Support : Fixed | No. of Bays : 2

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column			Design Forces and Sway Deflection: Beam		Alternate Design Sections for Beam and Column			
				Axial	Moment	$\Delta I/10^5$	Axial	Moment	ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
6.00	4.50	1 in 3	100	2 014	2 088	0.132	1 086	3 183	325/43.1	350/52.4	300/48.1	300/58.8
			150	2 014	2 088	0.189	1 086	3 183	350/49.5	350/52.4	350/56.9	350/67.4
			200	2 104	2 745	0.249	1 086	3 183	400/56.9	400/61.6	400/66.7	350/67.4
		1 in 4	100	2 120	2 186	0.119	1 004	3 546	325/43.1	300/44.2	300/48.1	300/58.8
			150	2 120	2 186	0.172	1 004	3 546	350/49.5	350/52.4	350/56.9	300/58.8
			200	2 120	2 186	0.226	1 004	3 546	400/56.9	400/61.6	400/66.7	350/67.4
		1 in 5	100	2 187	2 245	0.113	939	3 784	325/43.1	300/44.2	300/48.1	250/54.7
			150	2 187	2 245	0.164	939	3 784	350/49.5	350/52.4	350/56.9	300/58.8
			200	2 187	2 245	0.218	939	3 784	400/56.9	400/61.6	350/56.9	350/67.4
	6.00	1 in 3	100	1 930	2 324	0.335	960	3 459	400/56.9	400/61.6	400/66.7	350/67.4
			150	2 014	3 471	0.493	960	3 459	450/65.3	450/72.4	450/79.4	400/77.4
			200	2 100	4 649	0.656	907	3 599	500/75.0	500/86.9	450/79.4	450/87.2
		1 in 4	100	1 870	2 180	0.313	860	3 799	400/56.9	400/61.6	400/66.7	350/67.4
			150	1 941	3 255	0.462	860	3 799	450/65.3	450/72.4	450/79.4	400/77.4
			200	165	4 360	0.613	860	3 799	500/75.0	500/86.9	450/79.4	450/87.2
		1 in 5	100	1 841	2 121	0.304	786	4 020	400/56.9	400/61.6	400/66.7	350/67.4
			150	1 899	3 168	0.448	786	4 020	450/65.3	450/72.4	400/66.7	400/77.4
			200	98	4 243	0.600	786	4 020	500/75.0	500/86.9	450/79.4	450/87.2

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 41 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 12 m | Type of Support : Hinged | No. of Bays : 2

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
4.50	4.50	1 in 3	100	2 028	2 948	0.134	1 239	3 763	325/43.1	350/ 52.4	300/ 48.1	300/58.8
			150	2 028	2 948	0.181	1 239	3 763	350/49.5	350/ 52.4	350/ 56.9	300/63.0
			200	2 028	2 948	0.240	1 239	3 763	400/56.9	400/ 61.6	400/ 66.7	350/67.4
		1 in 4	100	2 136	3 130	0.116	1 185	4 277	325/43.1	300/ 44.2	300/ 48.1	250/54.7
			150	2 136	3 130	0.101	1 185	4 277	350/49.5	350/ 52.4	350/ 56.9	300/58.8
			200	2 136	3 130	0.209	1 185	4 277	400/56.9	400/ 61.6	350/ 56.9	350/67.4
		1 in 5	100	2 204	3 235	0.106	1 137	4 620	300/37.7	300/ 44.2	300/ 48.1	250/51.0
			150	2 204	3 235	0.150	1 137	4 620	350/49.5	350/ 52.4	350/ 56.9	300/58.8
			200	2 204	3 235	0.196	1 137	4 620	400/56.9	350/ 52.4	350/ 56.9	350/67.4
	6.00	1 in 3	100	1 976	2 730	0.311	1 066	4 171	400/56.9	400/ 61.6	400/ 66.7	350/67.4
			150	1 976	2 730	0.448	1 066	4 171	450/65.3	450/ 72.4	400/ 66.7	400/77.4
			200	1 976	2 730	0.602	1 066	4 171	500/75.0	500/ 86.9	450/ 79.4	450/87.2
		1 in 4	100	2 083	2 863	0.281	986	4 654	400/56.9	400/ 61.6	350/ 56.9	350/67.4
			150	2 083	2 863	0.406	986	4 654	450/65.3	450/ 72.4	400/ 66.7	400/77.4
			200	2 083	2 863	0.534	986	4 654	500/75.0	450/ 72.4	450/ 79.4	400/77.4
		1 in 5	100	2 151	2 942	0.266	923	4 970	400/56.9	400/ 61.6	350/ 56.9	350/67.4
			150	2 151	2 942	0.388	923	4 970	450/65.3	400/ 61.6	400/ 66.7	400/77.4
			200	2 151	2 942	0.318	923	4 970	450/65.3	450/ 72.4	450/ 79.4	400/77.4
	9.00	1 in 3	100	1 922	5 140	1.573	931	5 033	600/99.5	550/103.7	550/112.5	—
			150	1 103	5 748	2.343	1 228	6 676	—	600/122.6	600/133.7	—
			200	260	10 281	3.124	1 116	10 195	—	—	600/145.1	—
		1 in 4	100	1 853	4 869	1.486	801	5 115	550/86.3	550/103.7	500/ 95.2	—
			150	118	7 303	2.215	691	7 501	—	600/122.6	600/133.7	—
			200	406	9 737	2.962	1 000	10 277	—	—	600/133.7	—
		1 in 5	100	1 814	4 763	1.453	726	5 401	550/86.3	550/103.7	500/ 95.2	—
			150	48	7 144	2.174	633	7 612	—	600/122.6	550/112.5	—
			200	494	9 525	2.906	913	10 417	—	—	600/133.7	—

Δ = Side sway (cm), I = Moment of inertia (cm^4).

TABLE 42 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 12 m — Type of Support : Hinged — No. of Bays : 2

Spacing of Frame (m)	Column Height (m)	Roof Slope	Basic Wind Pressure (kg/m²)	Design Forces and Sway Deflection: Column Axial (kg)	Column Moment (kg. m)	Column $\Delta I/10^5$ (cm⁵)	Beam Axial (kg)	Beam Moment (kg. m)	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
6.00	4.50	1 in 3	100	2 792	4 059	0.181	1 707	5 181	350/49.5	350/ 52.4	350/ 56.9	300/58.8
			150	2 792	4 059	0.251	1 707	5 181	400/56.9	400/ 61.6	400/ 66.7	350/67.4
			200	2 792	4 059	0.322	1 707	5 181	450/65.3	450/ 72.4	400/ 66.7	400/77.4
		1 in 4	100	2 934	4 298	0.156	1 627	5 873	350/49.5	350/ 52.4	350/ 56.9	300/58.8
			150	2 934	4 298	0.217	1 627	5 873	400/56.9	400/ 61.6	350/ 56.9	350/67.4
			200	2 934	4 298	0.280	1 627	5 873	400/56.9	400/ 61.6	400/ 66.7	350/72.4
		1 in 5	100	3 023	4 437	0.143	1 559	6 335	350/49.5	350/ 52.4	350/ 56.9	300/58.8
			150	3 023	4 437	0.202	1 559	6 335	400/56.9	400/ 61.6	350/ 56.9	350/67.4
			200	3 023	4 437	0.260	1 559	6 335	400/56.9	400/ 61.6	400/ 66.7	350/67.4
	6.00	1 in 3	100	2 720	3 759	0.417	1 468	5 742	450/65.3	450/ 72.4	400/ 66.7	400/77.4
			150	2 720	3 759	0.600	1 468	5 742	500/75.0	500/ 86.9	450/ 79.4	450/87.2
			200	2 867	4 881	0.788	1 468	5 742	550/86.3	500/ 86.9	500/ 95.2	—
		1 in 4	100	2 860	3 932	0.376	1 354	6 391	450/65.3	400/ 61.6	400/ 66.7	350/72.4
			150	2 860	3 932	0.544	1 354	6 391	500/75.0	450/ 72.4	450/ 79.4	400/77.4
			200	2 860	3 932	0.716	1 354	6 391	500/75.0	500/ 86.9	500/ 95.2	450/87.2
		1 in 5	100	2 949	4 034	0.357	1 266	6 815	400/56.9	400/ 61.6	400/ 66.7	350/67.4
			150	2 949	4 034	0.519	1 266	6 815	450/65.3	450/ 72.4	450/ 79.4	400/77.4
			200	2 949	4 034	0.688	1 266	6 815	500/75.0	500/ 86.9	500/ 95.2	450/87.2
	9.00	1 in 3	100	2 712	6 854	2.102	1 271	6 862	600/99.5	600/122.6	550/112.5	—
			150	2 850	10 281	3.124	685	9 909	—	—	600/145.1	—
			200	197	13 707	4.165	1 462	13 518	—	—	—	—
		1 in 4	100	2 617	6 491	1.985	1 100	7 023	600/99.5	600/122.6	550/112.5	—
			150	304	9 737	2.955	900	9 930	—	—	600/133.7	—
			200	394	12 983	3.946	1 313	13 630	—	—	—	—
		1 in 5	100	2 564	6 350	1.939	995	7 407	600/99.5	600/122.6	550/112.5	—
			150	210	9 525	2.896	1 377	8 187	—	—	600/133.7	—
			200	513	12 700	3.872	1 199	13 819	—	—	—	—

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 43 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 18 m | Type of Support : Hinged | No. of Bays : 2

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
4.50	6.00	1 in 3	100	3 156	6 965	0.507	2 044	8 288	450/65.3	450/ 72.4	450/ 79.4	400/77.4
			150	3 156	6 965	0.687	2 044	8 288	500/75.0	500/ 86.9	500/ 95.2	450/87.2
			200	3 156	6 965	0.871	2 044	8 288	550/86.3	500/ 86.9	500/ 95.2	—
		1 in 4	100	3 317	7 427	0.426	1 978	9 481	450/65.3	450/ 72.4	400/ 66.7	400/77.4
			150	3 317	7 427	0.580	1 978	9 481	500/75.0	450/ 72.4	450/ 79.4	450/87.2
			200	3 317	7 427	0.738	1 978	9 481	500/75.0	500/ 86.9	500/ 95.2	450/87.2
		1 in 5	100	3 418	7 695	0.386	1 915	10 287	450/65.3	400/ 61.6	400/ 66.7	400/77.4
			150	3 418	7 695	0.530	1 915	10 287	450/65.3	450/ 72.4	450/ 79.4	400/77.4
			200	3 418	7 695	0.681	1 915	10 287	500/75.0	500/ 86.9	500/ 95.2	450/87.2
	9.00	1 in 3	100	3 043	6 307	2.0520	1 643	9 651	600/99.5	600/122.6	550/112.5	—
			150	3 200	8 238	2.987	1 643	9 651	—	—	600/133.7	—
			200	320	10 984	3.922	1 430	11 580	—	—	—	—
		1 in 4	100	3 201	6 598	1.856	1 516	10 745	600/99.5	550/103.7	550/112.5	—
			150	3 201	6 598	2.748	1 516	10 745	—	—	600/133.7	—
			200	2 433	9 050	3.633	1 405	12 843	—	—	—	—
		1 in 5	100	3 302	6 772	1.771	1 418	11 462	600/99.5	550/103.7	550/112.5	—
			150	3 302	6 772	2.616	1 418	11 462	—	600/122.6	600/133.7	—
			200	2 695	9 462	3.527	1 365	13 375	—	—	—	—
	12.00	1 in 3	100	3 026	9 300	5.308	1 450	10 502	—	—	—	—
			150	3 196	13 949	7.858	1 641	13 172	—	—	—	—
			200	280	18 599	10.418	2 002	16 219	—	—	—	—
		1 in 4	100	2 923	8 721	4.963	1 299	11 528	—	—	—	—
			150	293	13 082	7.366	968	13 832	—	—	—	—
			200	492	17 442	9.848	1 426	19 132	—	—	—	—
		1 in 5	100	2 866	8 487	4.825	1 186	12 193	—	—	—	—
			150	192	12 731	7.198	906	14 132	—	—	—	—
			200	621	16 975	9.639	1 326	19 515	—	—	—	—

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 44 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 18 m — Type of Support : Hinged — No. of Bays : 2

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
6.00	6.00	1 in 3	100	4 341	9 582	0.687	2 811	11 401	500/75.0	500/ 86.9	500/ 95.2	450/87.2
			150	4 341	9 582	0.927	2 811	11 401	550/86.3	550/103.7	500/ 95.2	—
			200	4 341	9 582	1.173	2 811	11 401	600/99.5	550/103.7	550/112.5	—
		1 in 4	100	4 552	10 191	0.577	2 714	13 011	500/75.0	450/ 72.4	450/ 79.4	450/87.2
			150	4 552	10 191	0.783	2 714	13 011	550/86.3	500/ 86.9	500/ 95.2	—
			200	4 552	10 191	0.994	2 714	13 011	550/86.3	550/103.7	500/ 95.2	—
		1 in 5	100	4 684	10 545	0.522	2 624	14 098	500/75.0	450/ 72.4	450/ 79.4	400/77.4
			150	4 684	10 545	0.714	2 624	14 098	500/75.0	500/ 86.9	500/ 95.2	450/87.2
			200	4 684	10 545	0.911	2 624	14 098	550/86.3	550/103.7	500/ 95.2	—
	9.00	1 in 3	100	4 186	8 676	2.751	2 259	13 276	—	—	600/133.7	—
			150	4 484	10 984	3.998	2 259	13 276	—	—	—	—
			200	1 565	11 770	5.245	1 847	16 023	—	—	—	—
		1 in 4	100	4 392	9 054	2.486	2 080	14 745	—	600/122.6	600/133.7	—
			150	4 392	9 054	3.630	2 080	14 745	—	—	—	—
			200	3 137	11 873	4.832	1 832	16 931	—	—	—	—
		1 in 5	100	4 525	9 280	2.372	1 943	15 708	—	600/122.6	600/133.7	—
			150	4 219	9 493	3.479	1 943	15 708	—	—	—	—
			200	3 501	12 427	4.692	1 783	17 645	—	—	—	—
	12.00	1 in 3	100	4 257	12 399	7.0945	1 995	14 446	—	—	—	—
			150	4 484	18 599	10.496	2 233	17 896	—	—	—	—
			200	152	24 799	13.896	2 022	24 874	—	—	—	—
		1 in 4	100	4 117	11 628	6.629	1 782	15 819	—	—	—	—
			150	4 301	17 442	9.833	1 258	18 272	—	—	—	—
			200	437	23 256	13.117	2 359	20 234	—	—	—	—
		1 in 5	100	4 308	11 316	6.443	1 625	16 710	—	—	—	—
			150	4 196	16 975	9.587	1 179	18 677	—	—	—	—
			200	611	22 633	12.841	1 738	25 854	—	—	—	—

Δ = Side sway (cm), I = Moment of inertia (cm^4).

TABLE 45 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 24 m | Type of Support : Hinged | No. of Bays : 2

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
4.50	9.00	1 in 3	100	4 276	12 437	2.161	2 614	15 872	—	—	600/133.7	—
			150	4 276	12 437	3.887	2 614	15 872	—	—	—	—
			200	4 276	12 437	5.0126	2 614	15 872	—	—	—	—
		1 in 4	100	4 486	13 146	2.379	2 489	17 962	—	600/122.6	600/133.7	—
			150	4 486	13 146	3.366	2 489	17 962	—	—	—	—
			200	4 486	13 146	4.439	2 489	17 962	—	—	—	—
		1 in 5	100	4 618	13 559	2.198	2 382	19 359	—	600/122.6	600/133.7	—
			150	4 618	13 559	3.143	2 382	19 359	—	—	600/145.1	—
			200	4 618	13 559	4.269	2 382	19 359	—	—	—	—
	12.00	1 in 3	100	4 166	11 512	6.510	2 248	17 597	—	—	—	—
			150	4 446	14 644	9.473	2 248	17 597	—	—	—	—
			200	248	19 525	12.425	1 950	20 910	—	—	—	—
		1 in 4	100	4 393	12 020	5.883	2 071	19 552	—	—	—	—
			150	4 279	13 263	8.602	2 071	19 552	—	—	—	—
			200	504	17 684	11.448	1 837	22 601	—	—	—	—
		1 in 5	100	4 505	12 324	5.618	1 934	20 833	—	—	—	—
			150	4 505	12 324	8.241	1 934	20 833	—	—	—	—
			200	3 515	16 598	11.119	1 934	20 833	—	—	—	—

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 46 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 24 m | Type of Support : Hinged | No. of Bays : 2

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
6.00	9.00	1 in 3	100	5 878	17 095	3.717	3 593	21 817	—	—	—	—
			150	5 878	17 095	5.225	3 593	21 817	—	—	—	—
			200	5 878	17 095	6.722	3 593	21 817	—	—	—	—
		1 in 4	100	6 151	18 028	3.207	3 413	24 632	—	—	600/145.1	—
			150	6 151	18 028	4.524	3 413	24 632	—	—	—	—
			200	6 151	18 028	5.883	3 413	24 632	—	—	—	—
		1 in 5	100	6 325	18 570	2.963	3 263	26 514	—	—	600/133.7	—
			150	6 325	18 570	4.205	3 263	26 514	—	—	—	—
			200	6 325	18 570	5.671	3 263	26 514	—	—	—	—
	12.00	1 in 3	100	5 726	15 824	8.730	3 090	24 187	—	—	—	—
			150	6 217	19 525	12.680	3 090	24 187	—	—	—	—
			200	2 195	21 230	16.640	2 670	28 424	—	—	—	—
		1 in 4	100	5 996	16 484	7.891	2 840	26 812	—	—	—	—
			150	5 990	17 684	11.501	2 840	26 812	—	—	—	—
			200	384	23 579	15.229	2 394	29 792	—	—	—	—
		1 in 5	100	6 170	16 878	7.519	2 649	28 533	—	—	—	—
			150	6 170	16 878	11.013	2 649	28 533	—	—	—	—
			200	4 565	21 795	14.793	2 649	28 533	—	—	—	—

Δ = Side sway (cm), I = Moment of inertia (cm^4).

TABLE 47 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 9 m | Type of Support : Hinged | No. of Bays : 3

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection					Alternate Design Sections for Beam and Column			
				Column			Beam					
				Axial	Moment	$\Delta I/10^5$	Axial	Moment	ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
4.50	4.50	1 in 3	100	1 497	1 634	0.0872	803	2 116	300/37.7	300/44.2	300/48.1	250/51.0
			150	1 497	1 634	0.124	803	2 116	325/43.1	300/44.2	300/48.1	300/58.8
			200	1 645	1 932	0.161	803	2 116	350/49.5	350/52.4	350/56.9	300/58.8
		1 in 4	100	1 577	1 704	0.0791	747	2 389	300/37.7	300/44.2	250/40.9	225/46.8
			150	1 577	1 704	0.112	747	2 389	325/43.1	300/44.2	300/48.1	250/51.0
			200	1 577	1 704	0.146	747	2 389	350/49.5	350/52.4	350/56.9	300/58.8
		1 in 5	100	1 627	1 743	0.0750	701	2 568	275/33.0	250/37.3	250/40.9	225/43.1
			150	1 627	1 743	0.106	701	2 568	325/43.1	300/44.2	300/48.1	250/51.0
			200	1 627	1 743	0.140	701	2 568	325/43.1	350/52.4	300/48.1	300/58.8
	6.00	1 in 3	100	1 457	1 465	0.209	702	2 305	350/49.5	350/52.4	350/56.9	300/58.8
			150	1 518	2 196	0.304	702	2 305	400/56.9	400/61.6	400/66.7	350/67.4
			200	1 633	2 951	0.401	702	2 305	450/65.3	450/72.4	400/66.7	400/77.4
		1 in 4	100	1 538	1 518	0.195	634	2 553	350/49.5	350/52.4	350/56.9	300/58.8
			150	1 504	2 102	0.285	634	2 553	400/56.9	400/61.6	350/56.9	350/67.4
			200	1 622	2 830	0.376	634	2 553	450/65.3	400/61.6	400/66.7	350/72.4
		1 in 5	100	1 590	1 550	0.188	582	2 713	325/43.1	350/52.4	300/48.1	300/58.8
			150	1 498	2 068	0.277	582	2 713	400/56.9	400/61.6	350/56.9	350/67.4
			200	1 026	2 174	0.367	582	2 713	400/56.9	400/61.6	400/66.7	350/67.4

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 48 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 9 m | Type of Support : Fixed | No. of Bays : 3

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
6.00	4.50	1 in 3	100	2 062	2 251	0.117	1 106	2 914	325/43.1	300/44.2	300/48.1	300/58.8
			150	2 062	2 251	0.116	1 106	2 914	350/49.5	350/52.4	350/56.9	300/58.8
			200	2 298	2 576	0.215	1 106	2 914	400/56.9	400/61.6	350/56.9	350/67.4
		1 in 4	100	2 166	2 341	0.105	1 026	3 282	300/37.7	300/44.2	300/48.1	250/51.0
			150	2 166	2 341	0.150	1 026	3 282	350/49.5	350/52.4	350/56.9	300/58.8
			200	2 284	2 428	0.196	1 026	3 282	400/56.9	350/52.4	350/56.9	350/67.4
		1 in 5	100	2 232	2 392	0.0095	962	3 523	300/37.7	300/44.2	300/48.1	250/51.0
			150	2 232	2 392	0.143	962	3 523	325/43.1	350/52.4	350/56.9	300/58.8
			200	2 232	2 392	0.187	962	3 523	350/49.5	350/52.4	350/56.9	300/63.0
	6.00	1 in 3	100	2 007	2 018	0.279	968	3 175	400/56.9	400/61.6	350/56.9	350/67.4
			150	2 130	2 925	0.406	968	3 175	450/65.3	450/72.4	400/66.7	400/77.4
			200	2 284	3 932	0.537	968	3 175	500/75.0	450/72.4	450/79.4	400/77.4
		1 in 4	100	2 113	2 086	0.260	871	3 507	400/56.9	350/52.4	350/56.9	350/67.4
			150	2 109	2 799	0.380	871	3 507	450/65.3	400/61.6	400/66.7	350/72.4
			200	2 267	3 770	0.503	871	3 507	450/65.3	450/72.4	450/79.4	400/77.4
		1 in 5	100	2 181	2 126	0.252	799	3 721	350/49.5	350/52.4	350/56.9	350/67.4
			150	2 100	2 753	0.269	799	3 721	400/56.9	400/61.6	400/66.7	350/67.4
			200	2 259	3 712	0.489	799	3 721	450/65.3	450/72.4	450/79.4	400/77.4

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 49 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 12 m | Type of Support : Hinged | No. of Bays : 3

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column			Beam		Alternate Design Sections for Beam and Column			
				Axial	Moment	$\Delta I/10^5$	Axial	Moment	ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
4.50	4.50	1 in 3	100	2 079	3 188	0.134	1 297	3 527	325/43.1	350/ 52.4	300/ 48.1	300/58.8
			150	2 079	3 188	0.180	1 297	3 527	350/49.5	350/ 52.4	350/ 56.9	300/58.8
			200	2 079	3 188	0.228	1 297	3 527	400/56.9	400/ 61.6	400/ 66.7	350/67.4
		1 in 4	100	2 185	3 362	0.116	1 222	3 970	325/43.1	300/ 44.2	300/ 48.1	250/54.7
			150	2 185	3 362	0.155	1 222	3 970	350/49.5	350/ 52.4	350/ 56.9	300/58.8
			200	2 185	3 362	0.198	1 222	3 970	400/56.9	350/ 52.4	350/ 56.9	350/67.4
		1 in 5	100	2 251	3 455	0.105	1 176	4 285	300/37.7	300/ 44.2	300/ 48.1	250/51.0
			150	2 251	3 455	0.143	1 176	4 285	350/49.5	350/ 52.4	350/ 56.9	300/58.8
			200	2 251	3 455	0.184	1 176	4 285	350/49.5	350/ 52.4	350/ 56.9	300/63.0
	6.00	1 in 3	100	2 024	2 947	0.278	1 085	3 814	400/56.9	400/ 61.6	350/ 56.9	350/67.4
			150	2 024	2 947	0.393	1 085	3 814	450/65.3	400/ 61.6	400/ 66.7	400/77.4
			200	2 024	2 947	0.510	1 085	3 814	450/65.3	450/ 72.4	450/ 79.4	400/77.4
		1 in 4	100	2 129	3 070	0.250	1 008	4 302	350/49.5	350/ 52.4	350/ 56.9	300/63.0
			150	2 129	3 070	0.354	1 008	4 302	400/56.9	400/ 61.6	400/ 66.7	350/67.4
			200	2 225	3 238	0.463	1 008	4 302	450/65.3	450/ 72.4	450/ 79.4	400/77.4
		1 in 5	100	2 196	3 138	0.236	947	4 622	350/49.5	350/ 52.4	350/ 56.9	300/58.8
			150	2 196	3 138	0.338	947	4 622	400/56.9	400/ 61.6	400/ 66.7	350/67.4
			200	2 220	3 160	0.443	947	4 622	450/65.3	450/ 72.4	400/ 66.7	400/77.4
	9.00	1 in 3	100	2 011	4 201	1.276	700	4 819	550/86.3	500/ 86.9	500/ 95.2	—
			150	2 206	6 338	1.887	893	6 466	600/99.5	600/122.6	550/112.5	—
			200	2 401	8 476	2.500	845	8 404	—	600/122.6	600/133.7	—
		1 in 4	100	1 990	4 042	1.203	809	4 700	550/86.3	500/ 86.9	500/ 95.2	—
			150	2 188	6 109	1.787	788	6 247	600/99.5	550/103.7	550/112.5	—
			200	2 387	8 177	2.375	767	8 622	—	600/122.6	600/133.7	—
		1 in 5	100	1 980	3 986	1.175	735	4 974	550/86.3	500/ 86.9	500/ 95.2	—
			150	2 180	6 031	1.747	741	6 160	600/99.5	550/103.7	550/112.5	—
			200	2 380	8 077	2.323	698	8 816	—	600/122.6	600/133.7	—

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 50 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 12 m | Type of Support : Hinged | No. of Bays : 3

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
6.00	4.50	1 in 3	100	2 862	4 389	0.180	1 786	4 855	350/49.5	350/ 52.4	350/ 56.9	300/58.8
			150	2 862	4 389	0.242	1 786	4 855	400/56.9	400/ 61.6	400/ 66.7	350/67.4
			200	2 862	4 389	0.307	1 786	4 855	450/65.3	450/ 65.3	400/ 66.7	400/72.4
		1 in 4	100	3 000	4 617	0.155	1 678	5 452	350/49.5	350/ 52.4	350/ 56.9	300/58.8
			150	3 000	4 617	0.210	1 678	5 452	400/56.9	400/ 61.6	350/ 56.9	350/67.4
			200	3 000	4 617	0.266	1 678	5 452	400/56.9	400/ 61.6	400/ 66.7	350/67.4
		1 in 5	100	3 086	4 738	0.142	1 613	5 876	325/43.1	350/ 52.4	300/ 48.1	300/58.8
			150	3 086	4 738	0.194	1 613	5 876	400/56.9	350/ 52.4	350/ 56.9	350/67.4
			200	3 086	4 738	0.247	1 613	5 876	400/56.9	400/ 61.6	400/ 66.7	350/67.4
	6.00	1 in 3	100	2 786	4 057	0.375	1 494	5 251	450/65.3	400/ 61.6	400/ 66.7	350/72.4
			150	2 786	4 057	0.527	1 494	5 251	450/65.3	450/ 72.4	450/ 79.4	400/77.4
			200	3 122	4 578	0.684	1 494	5 251	500/75.0	500/ 86.9	500/ 95.2	450/87.2
		1 in 4	100	2 924	4 215	0.335	1 385	5 907	400/56.9	400/ 61.6	400/ 66.7	350/67.4
			150	2 924	4 215	0.476	1 385	5 907	450/65.3	450/ 72.4	450/ 79.4	400/77.4
			200	2 924	4 215	0.622	1 385	5 907	500/75.0	500/ 86.9	450/ 79.4	450/87.2
		1 in 5	100	3 011	4 303	0.316	1 298	6 339	400/56.9	400/ 61.6	400/ 66.7	350/67.4
			150	3 011	4 303	0.453	1 298	6 339	450/65.3	450/ 72.4	400/ 66.7	400/77.4
			200	3 011	4 303	0.593	1 298	6 339	500/75.0	500/ 86.9	450/ 79.4	450/87.2
	9.00	1 in 3	100	2 823	5 594	1.705	961	6 558	600/99.5	550/103.7	550/112.5	—
			150	3 083	8 445	2.523	1 219	8 755	—	600/122.6	600/133.7	—
			200	3 342	11 295	3.334	1 476	10 952	—	—	600/145.1	—
		1 in 4	100	2 792	5 381	1.610	1 110	6 455	600/99.5	550/103.7	550/112.5	—
			150	3 057	8 138	2.385	1 073	8 462	—	600/122.6	600/133.7	—
			200	3 322	10 894	3.169	1 310	10 563	—	—	600/145.1	—
		1 in 5	100	2 777	5 306	1.570	1 008	6 821	600/99.5	550/103.7	550/112.5	—
			150	3 044	8 033	2.332	1 007	8 346	—	600/122.6	600/133.7	—
			200	3 311	10 760	3.104	1 241	10 407	—	—	600/145.1	—

Δ = Side sway (cm), I = Moment of inertia (cm^4).

TABLE 51 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 18 m — Type of Support : Hinged — No. of Bays : 3

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
4.50	6.00	1 in 3	100	3 238	7 546	0.529	2 187	7 852	450/65.3	450/ 72.4	450/ 79.4	400/77.4
			150	3 238	7 546	0.696	2 187	7 852	500/75.0	500/ 86.9	500/ 95.2	450/87.2
			200	3 238	7 546	0.868	2 187	7 852	550/86.3	500/ 86.9	500/ 95.2	—
		1 in 4	100	3 396	8 000	0.448	2 088	8 909	450/65.3	450/ 72.4	400/ 66.7	400/77.4
			150	3 396	8 000	0.593	2 088	8 909	500/75.0	500/ 86.9	450/ 79.4	450/87.2
			200	3 396	8 000	0.741	2 088	8 909	500/75.0	500/ 86.9	500/ 95.2	450/87.2
		1 in 5	100	3 493	8 241	0.402	1 993	9 597	450/65.3	450/ 72.4	400/ 66.7	400/77.4
			150	3 493	8 241	0.539	1 993	9 597	500/75.0	450/ 72.4	450/ 79.4	400/77.4
			200	3 493	8 241	0.677	1 993	9 597	500/75.0	500/ 86.9	400/ 79.4	450/87.2
	9.00	1 in 3	100	3 118	6 814	1.812	1 672	8 815	600/99.5	550/103.7	550/112.5	—
			150	3 487	7 724	2.695	1 129	10 506	—	600/122.6	600/133.7	—
			200	3 808	10 304	3.379	1 296	12 887	—	—	—	—
		1 in 4	100	3 273	7 082	1.634	1 551	9 923	600/99.5	550/103.7	550/112.5	—
			150	3 465	7 278	2.356	1 551	9 923	—	600/122.6	600/133.7	—
			200	2 337	8 062	3.0784	1 122	12 386	—	—	600/133.7	—
		1 in 5	100	3 372	7 230	1.551	1 454	10 651	600/99.5	550/103.7	550/112.5	—
			150	3 372	7 230	2.250	1 454	10 651	—	600/122.6	600/133.7	—
			200	2 625	8 570	2.948	1 454	10 651	—	—	600/133.7	—
	12.00	1 in 3	100	3 162	7 811	4.387	1 017	9 982	—	—	600/145.1	—
			150	3 466	11 787	6.442	1 262	13 198	—	—	—	—
			200	3 771	15 763	8.495	1 507	16 413	—	—	—	—
		1 in 4	100	3 130	7 463	4.097	1 316	10 619	—	—	600/133.7	—
			150	3 440	11 297	6.0406	1 105	12 741	—	—	—	—
			200	3 751	15 127	7.995	1 144	16 382	—	—	—	—
		1 in 5	100	3 115	7 340	3.975	1 205	11 266	—	—	600/133.7	—
			150	3 428	11 123	5.877	1 036	12 866	—	—	—	—
			200	71	14 923	7.797	1 258	15 553	—	—	—	—

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 52 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 18 m — Type of Support : Hinged — No. of Bays : 3

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column			Beam		Alternate Design Sections for Beam and Column			
				Axial	Moment	$\Delta I/10^5$	Axial	Moment	ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
6.00	6.00	1 in 3	100	4 455	10 381	0.722	3 009	10 802	500/75.0	500/ 86.9	500/ 95.2	450/87.2
			150	4 455	10 381	0.945	3 009	10 802	550/86.3	550/103.7	500/ 95.2	—
			200	4 455	10 381	1.173	3 009	10 802	600/99.5	550/103.7	550/112.5	—
		1 in 4	100	4 661	10 978	0.610	2 865	12 225	500/75.0	500/ 86.9	450/ 79.4	450/87.2
			150	4 661	10 978	0.803	2 865	12 225	550/86.3	500/ 86.9	500/ 95.2	—
			200	4 661	10 978	1.0005	2 865	12 225	550/86.3	550/103.7	500/ 95.2	—
		1 in 5	100	4 787	11 294	0.549	2 732	13 151	500/75.0	500/ 86.9	450/ 79.4	400/82.2
			150	4 787	11 294	0.729	2 732	13 151	500/75.0	500/ 86.9	500/ 95.2	450/87.2
			200	4 787	11 294	0.913	2 732	13 151	550/86.3	550/103.7	500/ 95.2	—
	9.00	1 in 3	100	4 289	9 374	2.436	2 301	12 126	—	600/122.6	600/133.7	—
			150	4 857	10 297	3.480	1 557	14 286	—	—	—	—
			200	5 286	13 738	4.525	1 780	17 461	—	—	—	—
		1 in 4	100	4 492	9 718	2.198	2 128	13 617	—	600/122.6	600/133.7	—
			150	4 492	9 718	3.157	2 128	13 617	—	—	600/145.1	—
			200	3 021	10 543	4.119	1 539	16 797	—	—	—	—
		1 in 5	100	4 621	9 908	2.081	1 992	14 596	600/99.5	600/122.6	500/112.5	—
			150	4 621	9 908	3.012	1 992	14 596	—	—	600/133.7	—
			200	3 406	14 226	3.944	1 438	16 514	—	—	—	—
	12.00	1 in 3	100	4 427	10 403	5.873	2 012	13 235	—	—	—	—
			150	4 833	15 704	8.611	1 726	17 891	—	—	—	—
			200	5 239	21 005	11.350	2 053	22 178	—	—	—	—
		1 in 4	100	4 380	9 940	5.480	1 806	14 572	—	—	—	—
			150	4 795	15 046	8.0710	1 509	17 283	—	—	—	—
			200	5 209	20 153	10.662	1 809	21 365	—	—	—	—
		1 in 5	100	4 359	9 768	5.814	1 652	15 439	—	—	—	—
			150	4 777	14 811	7.851	1 412	17 037	—	—	—	—
			200	301	19 878	10.393	1 392	22 335	—	—	—	—

Δ = Side sway (cm), I = Moment of inertia (cm^4).

TABLE 53 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 9 m — Type of Support : Hinged — No. of Bays : 4

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
4.50	4.50	1 in 3	100	1 517	1 719	0.0845	845	2 173	300/37.7	300/44.2	250/40.9	250/51.0
			150	1 517	1 719	0.117	845	2 173	325/43.1	300/44.2	300/48.1	300/58.8
			200	1 632	1 802	0.151	845	2 173	350/49.5	350/52.4	350/56.9	300/58.8
		1 in 4	100	1 593	1 778	0.0750	770	2 403	275/33.0	300/44.2	250/40.9	225/43.1
			150	1 593	1 778	0.105	770	2 403	300/37.7	300/44.2	300/48.1	250/51.0
			200	1 593	1 778	0.136	770	2 403	325/43.1	350/52.4	300/48.1	300/58.8
		1 in 5	100	1 641	1 808	0.0709	711	2 549	275/33.0	250/37.3	250/40.9	225/43.1
			150	1 641	1 808	0.0995	711	2 549	300/37.7	300/44.2	300/48.1	250/51.0
			200	1 641	1 808	0.129	711	2 549	325/43.1	350/52.4	300/48.1	300/58.8
	6.00	1 in 3	100	1 470	1 527	0.188	699	2 296	325/43.1	350/52.4	300/48.1	300/58.8
			150	1 517	1 950	0.271	699	2 296	400/56.9	400/61.6	350/56.9	350/67.4
			200	1 627	2 607	0.356	415	2 491	400/56.9	400/61.6	400/66.7	350/67.4
		1 in 4	100	1 547	1 569	0.174	640	2 519	325/43.1	350/52.4	300/48.1	300/58.8
			150	1 496	1 857	0.254	640	2 519	350/49.5	350/52.4	350/56.9	350/67.4
			200	1 608	2 488	0.334	640	2 519	400/56.9	400/61.6	400/66.7	350/67.4
		1 in 5	100	1 597	1 592	0.168	588	2 692	325/43.1	350/52.4	300/48.1	300/58.8
			150	1 486	1 817	0.245	588	2 692	350/49.5	350/52.4	350/56.9	300/63.0
			200	1 598	2 439	0.324	588	2 692	400/56.9	400/61.6	400/66.7	350/67.4

Δ = Side sway (cm), I = Moment of inertia (cm^4).

TABLE 54 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 9 m | Type of Support : Fixed | No. of Bays : 4

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
6.00	4.50	1 in 3	100	2 089	2 367	0.113	1 164	2 992	325/43.1	300/44.2	300/48.1	250/54.7
			150	2 089	2 367	0.158	1 164	2 992	350/49.5	350/52.4	350/56.9	300/58.8
			200	2 281	2 408	0.203	1 164	2 992	400/56.9	400/61.6	350/56.9	350/67.4
		1 in 4	100	2 189	2 443	0.101	1 058	3 301	300/37.7	300/44.2	300/48.1	250/51.0
			150	2 189	2 443	0.142	1 058	3 301	325/43.1	350/52.4	300/48.1	300/58.8
			200	2 189	2 443	0.183	1 058	3 301	350/49.5	350/52.4	350/56.9	300/63.0
		1 in 5	100	2 251	2 480	0.0954	976	3 496	300/37.7	300/44.2	300/48.1	250/51.0
			150	2 251	2 480	0.134	976	3 496	325/43.1	350/52.4	300/48.1	300/58.8
			200	2 251	2 480	0.174	976	3 496	350/49.5	350/52.4	350/56.9	300/58.8
	6.00	1 in 3	100	2 024	2 103	0.252	963	3 163	350/49.5	350/52.4	350/56.9	350/67.4
			150	2 126	2 602	0.363	963	3 163	400/56.9	400/61.6	400/66.7	350/67.4
			200	2 275	3 477	0.477	853	3 334	450/65.3	450/72.4	450/79.4	400/77.4
		1 in 4	100	2 126	2 155	0.233	879	3 460	350/49.5	350/52.4	350/56.9	300/58.8
			150	2 099	2 475	0.338	879	3 460	400/56.9	400/61.6	400/66.7	350/67.4
			200	2 248	3 317	0.446	879	3 460	450/65.3	450/72.4	400/66.7	400/77.4
		1 in 5	100	2 191	2 183	0.225	806	3 693	350/49.5	350/52.4	350/56.9	300/58.8
			150	2 085	2 422	0.327	806	3 693	400/56.9	400/61.6	400/66.7	350/67.4
			200	2 234	3 251	0.433	806	3 693	450/65.3	450/72.4	400/66.7	400/77.4

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 55 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 12 m   Type of Support : Hinged   No. of Bays : 4

Spacing of Frame	Column Height	Roof Slope	Basic Wind Pressure	Design Forces and Sway Deflection: Column Axial	Column Moment	Column $\Delta I/10^5$	Beam Axial	Beam Moment	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
(m)	(m)		(kg/m²)	(kg)	(kg. m)	(cm⁵)	(kg)	(kg. m)				
4.50	4.50	1 in 3	100	2 115	3 375	0.138	1 425	3 638	325/43.1	350/ 52.4	300/ 48.1	300/58.8
			150	2 115	3 375	0.183	1 425	3 638	350/49.5	350/ 52.4	350/ 56.9	300/63.0
			200	2 115	3 375	0.229	1 425	3 638	400/56.9	400/ 61.6	400/ 66.7	350/67.4
		1 in 4	100	2 217	3 540	0.119	1 343	4 101	325/43.1	300/ 44.2	300/ 48.1	300/58.8
			150	2 217	3 540	0.158	1 343	4 101	350/49.5	350/ 52.4	350/ 56.9	300/58.8
			200	2 217	3 540	0.199	1 343	4 101	400/56.9	400/ 61.6	350/ 56.9	350/67.4
		1 in 5	100	2 279	3 618	0.108	1 268	4 395	325/43.1	300/ 44.2	300/ 48.1	250/51.0
			150	2 279	3 618	0.146	1 268	4 395	350/49.5	350/ 52.4	350/ 56.9	300/58.8
			200	2 279	3 618	0.184	1 268	4 395	350/49.5	350/ 52.4	350/ 56.9	300/63.0
	6.00	1 in 3	100	2 051	3 102	0.267	1 144	3 919	400/56.9	400/ 61.6	350/ 56.9	350/67.4
			150	2 051	3 102	0.372	1 144	3 919	400/56.9	400/ 61.6	400/ 66.7	350/72.4
			200	2 220	3 208	0.478	1 144	3 919	450/65.3	450/ 72.4	450/ 79.4	400/77.4
		1 in 4	100	2 151	3 205	0.239	1 041	4 330	350/49.5	350/ 52.4	350/ 56.9	300/58.8
			150	2 151	3 205	0.334	1 041	4 330	400/56.9	400/ 61.6	400/ 66.7	350/67.4
			200	2 151	3 205	0.443	1 041	4 330	450/65.3	450/ 72.4	400/ 66.7	400/77.4
		1 in 5	100	2 214	3 256	0.224	961	4 589	350/49.5	350/ 52.4	350/ 56.9	300/58.8
			150	2 214	3 256	0.316	961	4 589	400/56.9	400/ 61.6	400/ 66.7	350/67.4
			200	2 214	3 256	0.412	961	4 589	450/65.3	450/ 72.4	400/ 66.7	400/77.4
	9.00	1 in 3	100	2 014	3 675	1.122	551	4 546	550/86.3	500/ 86.9	500/ 95.2	450/87.2
			150	2 204	5 511	1.648	1 094	6 017	600/99.5	550/103.7	550/112.5	—
			200	2 394	7 346	2.175	1 351	7 565	—	600/122.6	600/133.7	—
		1 in 4	100	1 986	3 521	1.0563	815	4 666	500/75.0	500/ 86.9	500/ 95.2	450/87.2
			150	2 176	5 294	1.559	985	5 950	600/99.5	550/103.7	550/112.5	—
			200	2 366	7 068	2.0623	1 227	7 474	600/99.5	600/122.6	550/112.5	—
		1 in 5	100	1 972	3 459	1.0291	740	4 961	500/75.0	500/ 86.9	500/ 95.2	450/87.2
			150	2 161	5 211	1.523	937	5 942	550/86.3	550/103.7	550/112.5	—
			200	2 350	6 963	2.0173	1 176	7 462	600/99.5	600/122.6	550/112.5	—

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 56 ANALYSIS AND DESIGN RESULTS OF STEEL PORTAL FRAMES

Span = 12 m — Type of Support : Hinged — No. of Bays : 4

Spacing of Frame (m)	Column Height (m)	Roof Slope	Basic Wind Pressure (kg/m²)	Design Forces and Sway Deflection: Column Axial (kg)	Column Moment (kg. m)	Column $\Delta I/10^5$ (cm⁵)	Beam Axial (kg)	Beam Moment (kg. m)	Alternate Design Sections for Beam and Column: ISLB	ISMB	ISWB	ISHB
6.00	4.50	1 in 3	100	2 911	4 646	0.188	1 962	5 008	350/49.5	350/ 52.4	350/ 56.9	350/67.4
			150	2 911	4 646	0.248	1 962	5 008	400/56.9	400/ 61.6	400/ 66.7	350/67.4
			200	2 911	4 646	0.309	1 962	5 008	450/65.3	450/ 72.4	400/ 66.7	400/77.4
		1 in 4	100	3 045	4 861	0.161	1 845	5 632	350/49.5	350/ 52.4	350/ 56.9	300/58.8
			150	3 045	4 861	0.214	1 845	5 632	400/56.9	400/ 61.6	350/ 56.9	350/67.4
			200	3 045	4 861	0.269	1 845	5 632	400/56.9	400/ 61.6	400/ 66.7	350/67.4
		1 in 5	100	3 125	4 961	0.146	1 739	6 028	350/49.5	350/ 52.4	350/ 56.9	300/58.8
			150	3 125	4 961	0.196	1 739	6 028	400/56.9	350/ 52.4	350/ 56.9	350/67.4
			200	3 125	4 961	0.248	1 739	6 028	400/56.9	400/ 61.6	400/ 66.7	350/67.4
	6.00	1 in 3	100	2 823	4 270	0.361	1 574	5 395	400/56.9	400/ 61.6	400/ 66.7	350/67.4
			150	2 823	4 270	0.500	1 574	5 395	450/65.3	450/ 72.4	450/ 79.4	400/77.4
			200	3 100	4 286	0.641	1 574	5 395	500/75.0	500/ 86.9	450/ 79.4	450/87.2
		1 in 4	100	2 954	4 402	0.322	1 430	5 946	400/56.9	400/ 61.6	400/ 66.7	350/67.4
			150	2 954	4 402	0.450	1 430	5 946	450/65.3	450/ 72.4	400/ 66.7	400/77.4
			200	2 954	4 402	0.581	1 430	5 946	500/75.0	450/ 72.4	450/ 79.4	450/87.2
		1 in 5	100	3 037	4 466	0.301	1 318	6 295	400/56.9	400/ 61.6	400/ 66.7	350/67.4
			150	3 037	4 466	0.425	1 318	6 295	450/65.3	450/ 72.4	400/ 66.7	400/77.4
			200	3 037	4 465	0.552	1 318	6 294	500/75.0	450/ 72.4	450/ 79.4	400/82.2
	9.00	1 in 3	100	2 828	4 901	1.501	763	6 198	550/86.3	550/103.7	500/ 95.2	—
			150	3 081	7 348	2.203	1 486	8 143	—	600/122.6	600/133.7	—
			200	3 334	9 795	2.906	1 830	10 206	—	—	600/133.7	—
		1 in 4	100	2 789	4 692	1.412	1 119	6 407	550/86.3	550/103.7	500/ 95.2	—
			150	3 041	7 057	2.0827	1 336	8 054	600/99.5	600/122.6	550/112.5	—
			200	3 294	9 422	2.753	1 658	10 086	—	—	600/133.7	—
		1 in 5	100	2 768	4 607	1.375	1 015	6 803	550/86.3	550/103.7	500/ 95.2	—
			150	3 020	6 944	2.0336	1 269	8 043	600/99.5	600/122.6	550/112.5	—
			200	3 272	9 280	2.692	714	10 283	—	—	600/133.7	—

Δ = Side sway (cm), I = Moment of inertia (cm⁴).

TABLE 57 ANALYSIS RESULTS FOR NON-PRISMATIC FRAMES

Span : 24 m | Type of Support : Hinged | No. of Bays : 1

Spacing (m)	Column Height (m)	Roof Slope	Basic Wind Pressure	Node 1, 13 (Column) Axial (kg)	Node 1, 13 (Column) Shear (kg)	Node 1, 13 (Column) Moment (kg.m)	Node 4, 12 Axial (kg)	Node 4, 12 Shear (kg)	Node 4, 12 Moment (kg.m)	Node 8 Axial (kg)	Node 8 Shear (kg)	Node 8 Moment (kg.m)	$\Delta \times I/10^5$ (cm⁵) Side Sway at Eaves	$\Delta \times I/10^5$ (cm⁵) Vertical at Crown
4.5	9.0	1 in 3	100	4 420	1 598	14 382	2 774	3 268	6 652	1 656	950	5 958	2.121	1.255
			150	4 420	1 598	14 382	2 774	3 268	10 839	2 810	1 442	5 958	3.276	1.255
			200	4 420	1 598	16 877	3 524	3 611	15 254	3 963	1 934	6 577	4.440	1.334
		1 in 4	100	4 687	1 757	15 810	2 728	3 666	6 742	1 818	669	7 037	1.853	1.461
			150	4 687	1 757	15 810	2 728	3 666	10 770	2 614	998	7 037	2.866	1.461
			200	4 687	1 757	18 089	3 373	4 388	15 175	3 703	1 327	7 511	3.879	1.659
		1 in 5	100	4 860	1 862	16 753	2 684	3 924	7 150	1 921	505	7 936	1.740	1.608
			150	4 860	1 862	16 753	2 684	3 924	10 965	2 512	737	7 936	2.683	1.608
			200	4 860	1 862	19 149	3 308	4 911	15 445	3 571	970	8 276	3.625	1.860
	12.0	1 in 3	100	4 420	1 211	14 524	2 406	3 391	10 930	1 710	390	7 148	5.413	1.578
			150	4 420	1 211	17 256	2 406	3 391	17 225	2 819	2 077	7 148	8.247	1.578
			200	4 420	1 439	24 912	3 487	4 496	23 747	3 927	2 764	9 140	11.086	1.594
		1 in 4	100	4 688	1 315	15 771	2 298	3 773	10 444	1 585	1 087	8 404	4.915	1.788
			150	4 688	1 315	17 894	2 299	3 773	16 833	2 629	2 606	8 404	7.479	1.788
			200	4 688	1 510	25 765	3 343	5 271	23 222	3 673	2 124	10 170	10.043	1.944
		1 in 5	100	4 860	1 383	16 586	2 214	4 018	10 483	1 505	916	9 253	4.712	1.933
			150	4 860	1 383	18 572	2 244	4 018	16 892	2 508	1 339	9 253	7.157	1.933
			200	4 860	1 586	26 676	3 247	5 793	23 302	3 511	1 761	10 994	9.601	2.151

NOTE — For node numbers, refer Fig. 1.

TABLE 58 ANALYSIS RESULTS FOR NON-PRISMATIC FRAMES

Span : 24.0 m — Type of Support : Hinged — No. of Bays : 1

Spacing	Column Height	Roof Slope	Basic Wind Pressure	Node 1, 13 (Column)			Node 4, 12			Node 8			$\Delta \times I/10^5$ (cm^5)	
				Axial	Shear	Moment	Axial	Shear	Moment	Axial	Shear	Moment	Side Sway at Eaves	Vertical at Crown
(m)	(m)			(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)		
6.0	9.0	1 in 3	100	6 075	2 197	19 769	3 813	4 492	9 058	2 276	1 264	8 190	2.845	1.724
			150	6 075	2 197	19 769	3 813	4 492	14 263	3 695	1 920	8 190	4.351	1.724
			200	6 075	2 197	20 058	4 612	4 713	20 149	5 233	2 576	8 585	5.902	1.727
		1 in 4	100	6 427	2 410	21 681	3 740	5 027	9 245	2 493	892	9 650	2.456	2.003
			150	6 427	2 410	21 681	3 740	5 027	14 688	3 431	1 331	9 650	3.807	2.003
			200	6 427	2 410	23 668	4 419	5 746	20 041	4 885	1 769	9 817	5.158	2.157
		1 in 5	100	6 656	2 550	22 945	3 675	5 374	9 793	2 631	676	10 869	2.308	2.202
			150	6 656	2 550	22 945	3 675	5 374	14 426	3 298	986	10 869	3.565	2.202
			200	6 656	2 550	25 077	4 337	6 441	20 399	4 709	1 296	10 869	4.822	2.421
	12.0	1 in 3	100	6 075	1 664	19 965	3 308	4 661	14 088	2 241	1 854	9 826	7.239	2.168
			150	6 075	1 664	22 359	3 308	4 661	22 783	3 718	2 770	9 826	10.974	2.168
			200	6 075	1 881	32 767	4 575	5 890	31 479	5 196	3 687	11 968	14.760	2.168
		1 in 4	100	6 427	1 803	21 627	3 152	5 175	13 742	2 072	1 453	11 525	6.536	2.452
			150	6 427	1 803	23 410	3 152	5 175	22 261	3 465	2 145	11 525	9.955	2.452
			200	6 427	1 975	33 904	4 391	6 920	30 779	4 857	2 836	13 331	13.373	2.524
		1 in 5	100	6 656	1 894	22 717	3 032	5 503	13 793	1 987	1 227	11 984	6.269	2.648
			150	6 656	1 894	24 312	3 032	5 503	22 339	3 304	1 791	12 673	9.528	2.648
			200	6 656	2 076	35 117	4 270	7 615	30 886	4 642	2 354	14 421	12.787	2.798

NOTE — For node numbers, refer Fig. 1.

TABLE 59 ANALYSIS RESULTS FOR NON-PRISMATIC FRAMES

Span : 30 m | Type of Support : Hinged | No. of Bays : 1

Spacing	Column Height	Roof Slope	Basic Wind Pressure	Node 1, 13 (Column)			Node 4, 12			Node 8			$\Delta \times I/10^5$ (cm^5)	
				Axial	Shear	Moment	Axial	Shear	Moment	Axial	Shear	Moment	Side Sway at Eaves	Vertical at Crown
(m)	(m)			(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)		
4.5	9.0	1 in 3	100	5 667	2 503	22 519	3 987	4 047	9 723	2 553	935	8 268	2.608	2.579
			150	5 667	2 503	22 519	3 987	4 047	12 071	3 622	1 454	8 268	4.037	2.579
			200	5 667	2 503	22 519	4 595	4 047	17 398	5 172	1 972	8 268	5.535	2.655
		1 in 4	100	5 998	2 777	24 992	4 004	4 563	10 883	2 840	606	9 855	2.152	3.079
			150	5 998	2 777	24 992	4 004	4 563	12 265	3 423	925	9 855	3.415	3.079
			200	5 998	2 777	24 992	4 483	4 852	17 701	4 915	1 245	9 855	4.679	3.405
		1 in 5	100	6 213	2 961	26 645	4 000	4 902	11 648	3 025	409	11 064	1.975	3.441
			150	6 213	2 961	26 645	4 000	4 902	12 705	3 282	608	11 064	3.123	3.441
			200	6 213	2 961	26 645	4 388	5 506	18 319	4 734	807	11 064	4.271	3.883
	12.0	1 in 3	100	5 667	1 930	23 150	3 443	4 228	11 762	2 025	1 283	9 929	6.393	3.305
			150	5 667	1 930	23 150	3 443	4 228	18 528	3 441	1 939	9 929	9.771	3·005
			200	5 667	1 930	28 179	4 280	4 636	26 016	4 857	2 595	10 845	13.222	3.308
		1 in 4	100	5 998	2 111	25 324	3 357	4 275	10 884	2 193	928	11 740	5.595	3.818
			150	5 998	2 111	25 324	3 357	4 725	18 317	3 182	1 378	11 740	8.627	3.818
			200	5 998	2 111	29 957	4 082	5 604	25 750	4 514	1 829	12 324	11.658	4.110
		1 in 5	100	6 213	2 230	26 756	3 283	5 046	11 321	2 309	722	13 145	5.286	4.179
			150	6 213	2 230	26 756	3 283	5 046	18 577	3 081	1 053	13 145	8.124	4.179
			200	6 213	2 230	31 560	4 035	6 256	26 109	4 381	1 383	13 528	10.963	4.598

NOTE — For node numbers, refer Fig. 1.

TABLE 60 ANALYSIS RESULTS FOR NON-PRISMATIC FRAMES

Span : 30 m — Type of Support : Hinged — No. of Bays : 1

Spacing (m)	Column Height (m)	Roof Slope	Basic Wind Pressure	Node 1, 13 (Column) Axial (kg)	Node 1, 13 (Column) Shear (kg)	Node 1, 13 (Column) Moment (kg.m)	Node 4, 12 Axial (kg)	Node 4, 12 Shear (kg)	Node 4, 12 Moment (kg.m)	Node 8 Axial (kg)	Node 8 Shear (kg)	Node 8 Moment (kg.m)	$\Delta \times I/10^5$ (cm^5) Side Sway at Eaves	$\Delta \times I/10^5$ (cm^5) Vertical at Crown
6.0	9.0	1 in 3	100	7 783	3 437	30 931	5 476	5 559	13 354	3 507	1 239	11 356	3.511	3.54
			150	7 783	3 437	30 931	5 476	5 559	15 802	4 752	1 930	11 356	5.342	3.542
			200	7 783	3 437	30 931	6 007	5 559	22 905	6 818	1 513	11 356	7.346	3.542
		1 in 4	100	8 219	3 806	34 251	5 487	6 253	14 915	3 892	805	13 506	2.841	4.219
			150	8 219	3 806	34 251	5 487	6 253	16 050	4 484	1 231	13 506	4.525	4.219
			200	8 219	3 806	34 251	5 865	6 342	23 299	6 474	1 657	13 506	6.210	4.426
		1 in 5	100	8 504	4 053	36 471	5 475	6 710	15 944	4 141	545	15 145	2.610	4.710
			150	8 504	4 053	36 471	5 475	6 710	16 631	4 296	811	15 145	4.140	4.710
			200	8 504	4 053	36 471	5 744	7 211	24 115	6 231	1 076	15 145	5.671	5.055
	12.0	1 in 3	100	7 783	2 650	31 798	4 729	5 807	15 978	2 760	1 708	13 637	8.568	4.540
			150	7 783	2 650	31 798	4 729	5 807	24 410	4 527	2 583	13 637	12.984	4.530
			200	7 783	2 650	36 874	5 603	5 807	34 393	6 415	3 457	14 161	17.586	4.540
		1 in 4	100	8 219	2 893	34 705	4 600	6 475	14 684	3 006	1 239	16 089	7.425	5.232
			150	8 219	2 893	34 705	4 600	6 475	24 125	4 182	1 840	16 089	11.467	5.232
			200	8 219	2 893	39 237	5 349	7 340	34 036	5 958	1 785	16 111	15.509	5.338
		1 in 5	100	8 504	3 053	36 624	4 494	6 906	15 497	3 160	968	17 993	7.019	5.720
			150	8 504	3 053	36 624	4 494	6 906	24 468	4 047	1 408	17 993	10.803	5.720
			200	8 504	3 053	41 369	5 293	8 206	34 510	5 780	1 849	17 993	14.588	5.983

NOTE — For node numbers, refer Fig. 1.

TABLE 61 ANALYSIS RESULTS FOR NON-PRISMATIC FRAME

Span : 24 m | Type of Support : Fixed | No. of Bays : 1

				NODE 3, 15 (COLUMN)			NODE 1, 13 (COLUMN)			NODE 4, 12			NODE 8			$\Delta \times I/10^5$ (cm⁵)	
SPACING (m)	COLUMN HEIGHT (m)	ROOF SLOPE	BASIC WIND PRESSURE	Axial (kg)	Shear (kg)	Moment (kg.m)	Axial (kg)	Shear (kg)	Moment (kg.m)	Axial (kg)	Shear (kg)	Moment (kg.m)	Axial (kg)	Shear (kg)	Moment (kg.m)	Side Sway at Eaves	Vertical at Crown
4.5	9.0	1 in 3	100	4 420	2 607	10 645	4 420	2 607	12 810	3 731	2 949	5 349	2 613	541	4 304	0.373	0.844
			150	4 420	2 607	10 645	4 420	2 607	12 810	3 731	2 949	5 349	3 290	891	4 304	0.615	0.844
			200	4 420	2 607	10 645	4 420	2 607	12 810	4 289	3 070	5 891	4 729	1 241	4 304	0.868	0.896
		1 in 4	100	4 687	2 889	11 327	4 687	2 889	14 665	3 825	3 392	6 276	2 916	327	5 396	0.334	1.062
			150	4 687	2 889	11 327	4 687	2 889	14 665	3 825	3 392	6 276	3 202	534	5 396	0.563	1.062
			200	4 687	2 889	11 327	4 687	2 889	14 665	4 292	3 399	7 045	4 621	742	5 396	0.792	1.213
		1 in 5	100	4 860	3 063	11 636	4 860	3 063	15 922	3 861	3 689	6 895	3 098	186	6 189	0.318	1.224
			150	4 860	3 063	11 636	4 860	3 063	15 922	3 861	3 689	6 895	3 120	300	6 189	0.531	1.224
			200	4 860	3 063	11 636	4 860	3 063	15 922	4 254	3 971	7 906	4 517	414	6 189	0.745	1.428
	12.0	1 in 3	100	4 420	1 981	10 099	4 420	1 981	13 662	3 137	3 147	5 701	2 019	663	5 455	0.980	1.145
			150	4 420	1 981	11 750	4 420	1 981	13 662	3 137	3 147	5 898	3 053	1 035	5 455	1.555	1.145
			200	4 420	2 572	16 990	4 420	1 981	13 662	3 895	3 147	8 612	4 334	1 407	5 455	2.138	1.172
		1 in 4	100	4 687	2 154	10 567	4 687	2 154	15 272	3 112	3 570	6 442	2 203	425	6 552	0.897	1.370
			150	4 687	2 154	11 943	4 687	2 154	15 272	3 112	3 570	6 550	2 888	650	6 552	1.426	1.370
			200	4 687	2 766	17 202	4 687	2 154	15 272	3 787	3 749	9 511	4 117	875	6 552	1.955	1.515
		1 in 5	100	4 860	2 260	10 784	4 860	2 260	16 334	3 074	3 846	6 922	2 312	276	7 399	0.861	1.531
			150	4 860	2 260	12 191	4 860	2 260	16 334	3 074	3 846	7 061	2 764	408	7 399	1.360	1.531
			200	4 860	2 913	17 499	4 860	2 260	16 334	3 688	4 315	10 213	3 951	540	7 399	1.859	1.733

NOTE — For node numbers, refer Fig. 1.

TABLE 62 ANALYSIS RESULTS FOR NON-PRISMATIC FRAME

Span : 24 m　　Type of Support : Fixed　　No. of Bays : 1

Spacing (m)	Column Height (m)	Roof Slope	Basic Wind Pressure	Node 3, 15 (Column) Axial (kg)	Shear (kg)	Moment (kg.m)	Node 1, 13 (Column) Axial (kg)	Shear (kg)	Moment (kg.m)	Node 4, 12 Axial (kg)	Shear (kg)	Moment (kg.m)	Node 8 Axial (kg)	Shear (kg)	Moment (kg.m)	Δ × I/10⁵ (cm⁵) Side Sway at Eaves	Vertical at Crown
6.0	9.0	1 in 3	100	6 075	3 583	14 632	6 075	3 583	17 608	5 128	4 054	7 353	3 591	709	5 916	0.509	1.160
			150	6 075	3 583	14 632	6 075	3 583	17 608	5 128	4 054	7 353	4 306	1 175	5 916	0.809	1.160
			200	6 075	3 583	15 679	6 075	3 583	17 608	5 604	4 054	7 689	6 224	1 642	5 916	1.146	1.160
		1 in 4	100	6 427	3 961	15 534	6 427	3 961	20 111	5 246	4 651	8 606	3 999	428	7 400	0.435	1.456
			150	6 427	3 961	15 534	6 427	3 961	20 111	5 246	4 651	8 606	4 186	705	7 400	0.741	1.456
			200	6 427	3 961	16 390	6 427	3 961	20 111	5 613	4 651	9 214	6 079	982	7 400	1.046	1.577
		1 in 5	100	6 656	4 194	15 937	6 656	4 194	21 807	5 288	5 052	9 444	4 243	244	8 477	0.415	1.676
			150	6 656	4 194	15 937	6 656	4 194	21 807	5 288	5 052	9 444	4 243	397	8 477	0.700	1.676
			200	6 656	4 419	15 937	6 656	4 194	21 807	5 566	5 194	10 354	5 939	549	8 477	0.984	1.859
	12.0	1 in 3	100	6 075	2 722	13 881	6 075	2 722	18 779	4 311	4 326	7 836	2 775	877	7 498	1.322	1.573
			150	6 075	2 722	13 881	6 075	2 722	18 779	4 311	4 326	7 836	4 008	1 373	7 498	2.057	1.573
			200	6 075	3 369	22 341	6 075	2 722	18 779	5 096	4 326	11 306	5 717	1 869	7 498	2.835	1.573
		1 in 4	100	6 427	2 953	14 492	6 427	2 953	20 943	4 268	4 895	8 834	3 021	565	8 986	1.183	1.879
			150	6 427	2 953	14 492	6 427	2 953	20 943	4 268	4 895	8 834	3 788	865	8 986	1.889	1.879
			200	6 427	2 953	22 635	6 427	2 953	20 943	4 960	4 896	12 499	5 426	1 164	8 986	2.594	1.968
		1 in 5	100	6 656	3 096	14 769	6 656	3 096	22 371	4 210	5 267	9 480	3 166	369	10 134	1.137	2.097
			150	6 656	3 096	15 962	6 656	3 096	22 371	4 210	5 267	9 480	3 622	545	10 134	1.802	2.097
			200	6 656	3 822	23 039	6 656	3 096	22 371	4 836	5 267	13 430	5 205	721	10 134	2.468	2.255

NOTE — For node numbers, refer Fig. 1.

TABLE 63 ANALYSIS RESULTS FOR NON-PRISMATIC FRAME

Span : 30 m — Type of Support : Fixed — No. of Bays : 1

Spacing	Column Height	Roof Slope	Basic Wind Pressure	Node 3, 15 (Column)			Node 1, 13 (Column)			Node 4, 12			Node 8			$\Delta \times I/10^5$ (cm^5)	
				Axial	Shear	Moment	Axial	Shear	Moment	Axial	Shear	Moment	Axial	Shear	Moment	Side Sway at Eaves	Vertical at Crown
(m)	(m)			(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)		
4.5	9.0	1 in 3	100	5 667	4 062	17 527	5 667	4 062	19 022	5 466	3 554	7 784	4 032	610	5 529	0.515	1.593
			150	5 667	4 062	17 527	5 667	4 062	19 022	5 466	3 554	7 784	4 350	1 065	5 529	0.759	1.593
			200	5 667	4 062	17 527	5 667	4 062	19 022	5 763	3 602	7 784	6 340	1 520	5 529	1.104	1.617
		1 in 4	100	5 998	4 583	19 032	5 998	4 583	22 213	5 756	4 125	9 458	4 592	530	7 217	0.510	2.101
			150	5 998	4 583	19 032	5 998	4 583	22 213	5 756	4 125	9 458	4 592	691	7 217	0.710	2.101
			200	5 998	4 583	19 032	5 998	4 583	22 213	5 936	4 125	9 458	6 369	989	7 217	1.031	2.323
		1 in 5	100	6 213	4 911	19 747	6 213	4 911	24 446	5 912	4 520	10 620	4 937	354	8 495	0.484	2.497
			150	6 213	4 911	19 747	6 213	4 911	24 446	5 912	4 520	10 620	4 937	539	8 495	0.675	2.497
			200	6 213	4 911	19 747	6 213	4 911	24 446	5 991	4 619	10 620	6 337	761	8 495	0.976	2.828
	12.0	1 in 3	100	5 667	3 152	16 924	5 667	3 152	20 897	4 603	3 842	8 749	3 170	692	7 292	1.144	2.262
			150	5 667	3 152	16 924	5 667	3 152	20 897	4 603	3 842	8 749	3 978	1 131	7 292	1.823	2.262
			200	5 667	3 152	19 865	5 667	3 152	20 897	5 152	3 842	9 816	5 728	1 569	7 292	2.563	2.262
		1 in 4	100	5 998	3 470	17 893	5 998	3 470	23 740	4 675	4 395	10 150	3 512	422	9 030	0.998	2.807
			150	5 998	3 470	17 893	5 998	3 470	23 740	4 675	4 395	10 150	3 841	680	9 030	1.667	2.807
			200	5 998	3 470	20 592	5 998	3 470	23 740	5 123	4 395	11 530	5 556	939	9 030	2.337	3.045
		1 in 5	100	6 213	3 665	18 327	6 213	3 665	25 652	4 691	4 764	11 078	3 716	245	10 278	0.953	3.209
			150	6 213	3 665	18 327	6 213	3 665	25 652	4 691	4 764	11 078	3 724	387	10 278	1.578	3.209
			200	6 213	3 665	21 212	6 213	3 665	25 652	5 058	4 969	12 816	5 404	529	10 278	2.203	3.565

NOTE — For node numbers, refer Fig. 1.

TABLE 64 ANALYSIS RESULTS FOR NON-PRISMATIC FRAME

Span : 30 m | Type of Support : Fixed | No. of Bays : 1

Spacing	Column Height	Roof Slope	Basic Wind Pressure	Node 3, 15 (Column) Axial	Shear	Moment	Node 1, 13 (Column) Axial	Shear	Moment	Node 4, 12 Axial	Shear	Moment	Node 8 Axial	Shear	Moment	$\Delta \times I/10^5$ (cm^5) Side Sway at Eaves	Vertical at Crown
(m)	(m)			(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)		
6.0	9.0	1 in 3	100	7 783	5 579	24 074	7 783	5 579	26 127	7 507	4 881	10 692	5 538	1 026	75 595	0.708	2.187
			150	7 783	5 579	24 074	7 783	5 579	26 127	7 507	4 881	10 692	5 678	1 397	7 595	0.991	2.187
			200	7 783	5 579	24 074	7 783	5 579	26 127	7 520	4 881	10 692	8 331	2 004	7 595	1.451	2.187
		1 in 4	100	8 219	6 281	26 083	8 219	6 281	30 442	7 888	5 653	12 962	6 293	726	9 890	0.698	2.879
			150	8 219	6 281	26 083	8 219	6 281	30 442	7 888	5 653	12 962	6 293	907	9 890	0.928	2.879
			200	8 219	6 281	26 083	8 219	6 281	30 442	7 888	5 653	12 962	8 364	1 302	9 890	1.355	3.020
		1 in 5	100	8 504	6 722	27 029	8 504	6 722	33 462	8 092	6 187	14 536	6 758	485	11 629	0.662	3.418
			150	8 504	6 722	27 029	8 504	6 722	33 462	8 092	6 187	14 536	6 758	709	11 629	0.883	3.418
			200	8 504	6 722	27 029	8 504	6 722	33 462	8 092	6 187	14 536	8 317	1 005	11 629	1.285	3.682
	12.0	1 in 3	100	7 783	4 329	23 245	7 783	4 329	28 702	6 322	5 276	12 018	4 353	909	10 016	1.555	3.106
			150	7 783	4 329	23 245	7 783	4 329	28 702	6 322	5 276	12 018	5 208	1 493	10 016	2.400	3.106
			200	7 783	4 329	25 977	7 783	4 329	28 702	6 730	5 276	12 825	7 542	2 078	10 016	3.387	3.106
		1 in 4	100	8 219	4 755	24 522	8 219	4 755	32 535	6 407	6 023	13 910	4 813	555	12 375	1.305	3.847
			150	8 219	4 755	24 522	8 219	4 755	32 535	6 407	6 023	13 910	5 023	900	12 375	2.197	3.847
			200	8 219	4 755	26 957	8 219	4 755	32 535	6 701	6 023	15 091	7 310	1 245	12 375	3.090	3.956
		1 in 5	100	8 504	5 017	25 086	8 504	5 017	35 113	6 421	6 521	15 164	5 086	324	14 069	1.248	4.392
			150	8 504	5 017	25 086	8 504	5 017	35 113	6 421	6 521	15 164	5 086	513	14 069	2.081	4.392
			200	8 504	5 017	27 796	8 504	5 017	35 113	6 620	6 521	16 794	7 107	702	14 069	2.914	4.640

NOTE — For node numbers, refer Fig. 1.

TABLE 65 ANALYSIS RESULTS FOR NON-PRISMATIC FRAME

Span : 24 m — Type of Support : Fixed — No. of Bays : 1

Spacing	Column Height	Roof Slope	Basic Wind Pressure	Node 3, 15 (Column)			Node 1, 13 (Column)			Node 4, 12			Node 8			$\Delta \times I/10^5$ (cm^5)	
				Axial	Shear	Moment	Axial	Shear	Moment	Axial	Shear	Moment	Axial	Shear	Moment	Side Sway at Eaves	Vertical at Crown
(m)	(m)			(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)		
4.5	9.0	1 in 3	100	4 338	1 580	14 217	9 002	653	5 868	2 783	3 351	7 696	1 763	1 113	5 399	1.751	0.987
			150	4 338	1 580	14 217	9 002	979	8 803	2 783	3 351	8 185	2 972	1 700	5 399	2.459	0.987
			200	4 338	1 580	14 217	9 002	1 305	11 737	3 741	3 413	10 470	4 180	2 287	5 399	3.166	1.03
		1 in 4	100	4 557	1 698	15 279	9 634	551	4 954	2 702	3 807	8 988	1 793	939	6 388	1.492	1.148
			150	4 557	1 698	15 279	9 634	826	7 432	2 702	3 807	8 988	2 789	1 424	6 388	2.103	1.148
			200	4 557	1 698	15 279	9 634	1 102	9 909	3 605	3 807	9 183	3 935	1 908	6 388	2.744	1.298
		1 in 5	100	4 694	1 770	15 927	10 052	500	4 500	2 561	3 779	6 678	1 864	846	7 069	1.369	1.261
			150	4 694	1 770	15 927	10 052	750	6 750	2 561	3 779	6 678	2 657	1 274	7 069	1.939	1.261
			200	4 694	1 770	15 927	10 052	1 000	9 000	3 151	3 969	9 624	3 757	1 702	7 069	2.632	1.460
	12.0	1 in 3	100	4 241	1 141	13 685	9 195	822	9 857	2 396	3 582	8 905	2 044	1 406	6 407	3.987	1.188
			150	4 241	1 141	13 685	9 195	1 233	14 786	2 878	3 582	12 281	3 317	2 130	6 407	5.777	1.188
			200	4 241	1 141	15 687	9 195	1 643	19 714	4 150	3 582	15 656	3 790	2 854	6 407	3.567	1.187
		1 in 4	100	4 454	1 209	14 506	9 838	739	8 861	2 253	4 025	10 129	1 888	1 215	7 354	3.567	1.338
			150	4 454	1 209	14 506	9 838	1 108	13 292	2 746	4 025	11 209	3 075	1 833	7 354	5.192	1.338
			200	4 454	1 209	16 589	9 838	1 477	17 722	3 933	4 025	14 261	4 263	2 452	7 354	6.893	1.458
		1 in 5	100	4 590	1 251	15 009	10 260	701	8 406	2 138	4 309	10 946	1 780	1 114	7 987	3.381	1.441
			150	4 590	1 251	15 009	10 260	1 051	12 609	2 644	4 309	10 946	2 908	1 676	7 987	4.942	1.441
			200	4 590	1 251	17 594	10 260	1 402	16 813	3 772	4 474	14 240	4 036	2 238	7 987	6.671	1.616

NOTE — For node numbers, refer Fig. 1.

TABLE 66 ANALYSIS RESULTS FOR NON-PRISMATIC FRAME

Span : 24 m — Type of Support : Fixed — No. of Bays : 1

SPACING (m)	COLUMN HEIGHT (m)	ROOF SLOPE	BASIC WIND PRESSURE	NODE 1, 25 (COLUMN) Axial (kg)	Shear (kg)	Moment (kg.m)	NODE 13 (COLUMN) Axial (kg)	Shear (kg)	Moment (kg.m)	NODE 4, 12, 16, 24 Axial (kg)	Shear (kg)	Moment (kg.m)	NODE 8, 20 Axial (kg)	Shear (kg)	Moment (kg.m)	$\Delta \times I/10^5$ (cm^5) Side Sway at Eaves	Vertical at Crown
6.0	9.0	1 in 3	100	5 954	2 172	19 542	12 373	870	5 477	3 825	4 606	10 579	2 299	1 479	7 421	2.362	1.356
			150	5 964	2 172	19 542	12 373	1 305	11 737	3 825	4 606	11 464	3 911	2 262	7 421	3.305	1.356
			200	5 964	2 172	19 542	12 373	1 739	15 650	4 901	4 606	14 150	5 230	3 045	7 421	4.249	1.36
		1 in 4	100	6 248	2 329	20 954	13 211	735	6 606	3 705	5 220	12 326	2 458	1 250	8 761	2.011	1.574
			150	6 248	2 329	20 954	13 211	1 102	9 909	3 705	5 220	12 326	3 667	1 896	8 761	2.825	1.574
			200	6 248	2 329	20 954	13 211	1 469	13 213	4 730	5 220	12 476	5 195	2 542	8 761	3.839	1.686
		1 in 5	100	6 428	2 424	21 813	13 767	667	6 000	3 597	5 622	13 521	2 552	1 126	9 682	1.842	1.727
			150	6 428	2 424	21 813	13 767	1 000	9 000	3 597	5 622	13 521	3 492	1 697	9 682	2.604	1.727
			200	6 428	2 424	21 813	13 767	1 334	12 000	4 587	5 622	13 521	4 959	2 269	9 682	3.492	1.90
	12.0	1 in 3	100	5 830	1 568	18 811	12 369	1 096	9 200	3 294	4 924	12 238	2 685	1 870	8 807	5.348	1.632
			150	5 830	1 568	18 811	12 639	1 643	19 714	3 762	4 924	16 544	4 383	2 836	8 807	7.734	1.632
			200	5 830	1 568	21 339	12 369	2 191	26 286	5 459	4 924	21 044	6 080	3 082	8 807	10.121	1.632
		1 in 4	100	6 108	1 658	19 893	13 491	985	11 815	3 089	5 519	13 891	2 479	1 618	10 085	4.781	1.835
			150	6 108	1 658	19 893	13 491	1 477	17 722	3 597	5 519	15 108	4 062	2 443	10 085	6.947	1.835
			200	6 108	1 658	21 705	13 491	1 970	23 630	5 180	5 519	19 177	5 645	3 268	10 085	9.166	1.894
		1 in 5	100	6 286	1 714	20 557	14 052	935	7 846	2 928	5 901	14 992	2 336	1 484	10 939	4.529	1.973
			150	6 286	1 714	20 557	14 052	1 402	16 813	3 467	5 901	14 992	3 840	2 234	10 939	6.609	1.973
			200	4 286	1 714	23 050	14 052	1 869	22 417	4 971	5 901	18 831	5 343	2 983		8.875	2.102

NOTE — For node numbers, refer Fig. 1.

TABLE 67 ANALYSIS RESULTS FOR NON-PRISMATIC FRAMES

Span : 24 m — Type of Support : Fixed — No. of Bays : 2

Spacing (m)	Column Height (m)	Roof Slope	Basic Wind Pressure	Node 3, 27 (Column) Axial (kg)	Node 3, 27 (Column) Shear (kg)	Node 3, 27 (Column) Moment (kg.m)	Node 1, 25 (Column) Axial (kg)	Node 1, 25 (Column) Shear (kg)	Node 1, 25 (Column) Moment (kg.m)	Node 4, 12, 16, 24 Axial (kg)	Node 4, 12, 16, 24 Shear (kg)	Node 4, 12, 16, 24 Moment (kg.m)	Node 8, 20 (Column) Axial (kg)	Node 8, 20 (Column) Shear (kg)	Node 8, 20 (Column) Moment (kg.m)	Node 13 (Column) Axial (kg)	Node 13 (Column) Shear (kg)	Node 13 (Column) Moment (kg.m)	Node 15 Axial (kg)	Node 15 Shear (kg)	Node 15 Moment (kg.m)	$\Delta \times I/10^5$ (cm^5) Side Sway at Eaves	$\Delta \times I/10^5$ (cm^5) Vertical at Crown
4.5	9.0	1 in 3	100	4 422	2 841	12 801	4 442	2 841	12 760	3 953	2 878	5 482	2 835	779	3 638	8 834	478	1 463	8 834	478	2 833	0.474	0.650
			150	4 422	2 841	12 801	4 442	2 841	12 760	3 953	2 878	5 482	3 379	1 262	3 638	8 834	717	2 195	8 834	717	4 250	0.603	0.650
			200	4 422	2 841	12 801	4 442	2 841	12 760	4 437	3 009	5 482	4 877	1 745	3 766	8 834	955	2 926	8 834	955	5 666	0.731	0.679
		1 in 4	100	4 657	3 109	13 463	4 657	3 109	14 511	4 046	3 368	6 907	3 137	663	4 731	9 434	350	969	9 434	350	2 175	0.399	0.837
			150	4 657	3 109	13 463	4 657	3 109	14 511	4 046	3 368	6 907	3 312	1 054	4 731	9 334	525	1 454	9 434	525	3 263	0.493	0.837
			200	4 657	3 109	13 463	4 657	3 109	14 511	4 465	3 368	6 907	4 795	1 445	4 731	9 434	699	1 939	9 434	699	4 351	0.593	0.953
		1 in 5	100	4 800	3 248	13 601	4 800	3 248	15 626	4 054	3 593	7 988	3 292	593	5 551	9 840	280	668	9 840	280	1 842	0.372	0.977
			150	4 800	3 248	13 601	4 800	3 248	15 626	4 054	3 711	7 988	3 292	927	5 517	9 840	419	1 002	9 840	419	2 764	0.432	0.977
			200	4 800	3 248	13 601	4 800	3 248	15 626	4 414	3 711	7 988	4 678	1 261	5 517	9 840	559	1 337	9 840	559	3 685	0.581	1.140
	12.0	1 in 3	100	4 353	2 083	11 629	4 353	2 083	13 357	3 254	3 178	6 907	2 136	916	4 798	8 971	609	2 713	8 971	609	4 590	0.960	0.877
			150	4 353	2 083	11 620	4 353	2 083	13 357	3 254	3 178	6 907	3 098	1 433	4 798	8 971	913	4 070	8 971	913	6 885	1.292	0.877
			200	4 353	2 083	11 620	4 353	2 083	13 357	3 971	3 245	6 907	4 410	1 951	4 798	8 971	1 218	5 426	8 971	1 218	9 181	1.624	0.887
		1 in 4	100	4 574	2 212	11 840	4 574	2 212	14 703	3 197	3 665	8 384	2 287	776	5 896	9 599	510	2 185	9 599	510	3 927	0.821	1.060
			150	4 574	2 212	11 840	4 574	2 212	14 703	3 197	3 665	8 348	2 929	1 199	5 878	9 599	764	3 277	9 599	764	5 890	1.107	1.060
			200	4 574	2 212	11 840	4 574	2 212	14 703	3 852	3 665	8 384	4 181	1 622	5 896	9 599	1 019	4 370	9 599	1 019	7 854	1.415	1.173
		1 in 5	100	4 711	2 276	11 785	4 711	2 276	15 522	3 119	3 989	9 347	2 357	695	6 664	10 019	459	1 892	10 019	459	3 614	0.747	1.190
			150	4 711	2 276	11 785	4 711	2 276	15 522	3 119	3 989	9 347	2 789	1 062	6 664	10 019	689	2 838	10 019	689	5 422	1.015	1.190
			200	4 711	2 276	11 785	4 711	2 276	15 522	3 726	3 989	9 347	3 790	1 430	6 664	10 019	918	3 784	10 019	918	7 229	1.392	1.353

NOTE — For node numbers, refer Fig. 1.

TABLE 68 ANALYSIS RESULTS FOR NON-PRISMATIC FRAMES

Span : 24 m — Type of Support : Fixed — No. of Bays : 2

Spacing	Column Height	Roof Slope	Basic Wind Pressure	Node 3, 27 (Column)			Node 1, 25 (Column)			Node 4, 12, 16, 24			Node 8, 20 (Column)			Node 13 (Column)			Node 15			Δ × I/10³ (cm⁵)	
				Axial	Shear	Moment	Axial	Shear	Moment	Axial	Shear	Moment	Axial	Shear	Moment	Axial	Shear	Moment	Axial	Shear	Moment	Side Sway at Eaves	Vertical at Crown
(m)	(m)			(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)		
6.0	9.0	1 in 3	100	6 078	3 905	17 596	6 078	3 905	17 540	5 434	3 955	7 535	3 897	1 024	5 001	12 143	637	1 952	12 143	637	3 777	0.649	0.893
			150	6 078	3 905	17 596	6 078	3 905	17 540	5 434	3 955	7 535	4 418	1 667	5 001	12 143	956	2 926	12 143	956	5 666	0.821	0.893
			200	6 078	3 905	17 596	6 078	3 905	17 540	5 794	3 963	7 535	6 414	2 311	5 001	12 143	1 274	3 902	12 143	1 274	7 555	0.992	0.893
		1 in 4	100	6 386	4 263	18 462	6 386	4 263	19 900	5 549	4 618	9 472	4 302	875	6 488	12 937	466	1 292	12 937	466	2 900	0.547	1.148
			150	6 386	4 263	18 462	6 386	4 263	19 900	5 549	4 618	9 472	4 327	1 396	6 488	12 937	699	1 239	12 937	699	4 351	0.673	1.148
			200	6 386	4 263	18 462	6 386	4 263	19 900	5 838	4 618	9 427	6 304	1 918	6 488	12 937	932	2 586	12 937	932	5 801	0.805	1.238
		1 in 5	100	6 574	4 448	18 628	6 774	4 448	21 402	5 553	5 083	10 941	4 509	784	7 603	13 477	373	891	13 477	373	2 457	0.510	1.339
			150	6 574	4 448	18 628	6 574	4 448	21 402	5 553	5 083	10 941	4 509	1 230	7 603	13 477	559	1 337	13 477	559	3 685	0.590	1.339
			200	6 574	4 448	18 628	6 574	4 448	21 402	5 575	5 083	10 941	6 148	1 675	7 603	13 477	745	1 782	13 477	745	4 914	0.761	1.484
	12.0	1 in 3	100	5 984	2 863	15 984	5 984	2 863	18 360	4 473	4 368	9 494	2 937	1 212	6 995	12 331	812	3 617	12 331	812	6 120	1.304	1.205
			150	5 984	2 863	15 984	5 984	2 863	18 360	4 473	4 368	9 494	4 064	1 902	6 995	12 331	1 218	5 426	12 331	1 218	9 181	1.731	1.205
			200	5 984	2 863	18 228	5 984	2 863	18 360	5 193	4 368	9 494	5 814	2 591	6 995	12 331	1 624	7 235	12 331	1 624	12 241	2.128	1.205
		1 in 4	100	6 272	3 034	16 237	6 272	3 034	20 163	4 384	5 026	11 448	3 137	1 029	8 086	13 164	680	2 913	13 164	680	5 236	1.114	1.454
			150	6 272	3 034	16 237	6 272	3 034	20 163	4 384	5 026	11 448	3 840	1 593	8 086	13 164	1 019	4 370	13 164	1 019	7 854	1.496	1.454
			200	6 272	3 034	16 238	6 272	3 034	20 163	5 044	5 026	11 448	5 510	2 156	8 086	13 164	1 359	5 826	13 164	1 359	10 472	1.878	1.523
		1 in 5	100	6 451	3 117	16 141	6 451	3 117	21 259	4 272	5 464	12 802	3 227	923	9 127	13 721	612	2 523	13 721	612	4 819	1.013	1.629
			150	6 451	3 117	16 141	6 451	3 117	21 259	4 272	5 464	12 802	3 654	1 413	9 127	13 721	918	3 784	13 721	918	7 229	0.297	1.629
			200	6 451	3 117	16 970	6 451	3 117	21 259	4 883	5 464	12 802	5 255	1 903	9 127	13 721	1 224	5 046	13 721	1 224	9 639	1.839	1.761

NOTE — For node numbers, refer Fig. 1.

TABLE 69 FOUNDATION FORCES FOR STEEL PORTAL FRAMES

Span : 9 m | Spacing of Frame : 4.5 m | Type of Support : Fixed

Column Height	No. of Bays	Foundation Location‡	Foundation Forces* Due To										
			Dead Load			Live Load			Wind Load† p = 200 kg/m²				
									Maximum moment combination			Maximum uplift combination	
			Downward force	Horizontal force	Moment	Downward force	Horizontal force	Moment	*Downward force*	*Horizontal force*	*Moment*	*Downward force*	*Moment*
(m)		(kg)	(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)	(kg)	(kg.m)
4.5	1	1	762	−302	563	982	−396	694	−2025	2 083	−2 721	—	—
	2	1	741	−312	633	937	−388	731	−281	−1 246	1 200	−1 749	−1 137
		2	1 566	0	0	2 054	0	0	−1 433	−1 269	1 254	−3 792	0
	3	1	759	−346	735	956	−426	841	−309	−1 213	1 119	−1 782	−1 319
		2	1 527	0	98	989	0	75	−674	−1 360	1 376	−3 685	−125
	4	1	771	−372	814	969	−457	934	−307	−1 214	1 118	−1 819	1 515
		2	1 531	−71	208	1 994	−64	198	−652	−1 347	1 353	−3 693	−330
		3	1 494	0	0	1 929	0	0	−878	−1 155	939	−3 588	0
6.0	1	1	762	−218	516	982	−281	629	−921	2 400	−3 943	−2 169	−3 797
	2	1	722	−212	538	914	−257	612	−1 084	−1 757	2 139	−1 781	−2 854
		2	1 604	0	0	2 100	0	0	−1 454	−1 675	2 090	−3 851	0
	3	1	740	−235	621	933	−281	694	−1 156	−1 668	1 821	−1 772	−2 621
		2	1 546	0	54	2 012	0	0	680	−1 674	1 976	−3 717	0
	4	1	750	−252	689	942	−298	761	−256	−1 632	1 680	−1 782	−1 118
		2	1 551	0	147	2 021	0	113	650	−1 620	1 805	−3 730	−190
		3	1 494	0	0	1 928	0	0	−862	−1 504	1 490	−3 590	0

*On the foundation downward force positive, horizontal force to the left positive, clockwise moment positive. The most conservative values of forces from frames having 1 in 3, 1 in 4 and 1 in 5 roof slopes are presented.

†To obtain forces due to basic wind pressure of 100 and 150 kg/m² reduce the forces given in the table proportionately.

‡Refer to Fig. 1 for foundation location.

NOTE — *Add 30 kg/m² to foundation forces to include the dead load of AC sheeting and girts in wall claddings.*

TABLE 70 FOUNDATION FORCES FOR STEEL PORTAL FRAMES

Span : 9 m — Spacing of Frame : 4.5 m — Type of Support : Hinged

Column Height (m)	No. of Bays	Foundation Location‡	Foundation Forces* Due To: Dead Load — Downward force (kg)	Dead Load — Horizontal force (kg)	Live Load — Downward force (kg)	Live Load — Horizontal force (kg)	Wind Load† $p = 200$ kg/m — Downward force (kg)	Wind Load† $p = 200$ kg/m — Horizontal force (kg)
4.5	1	1	762	−180	982	−237	−2 398	1 844
	2	1	719	−166	911	−208	−1 902	−1 248
		2	1 611	0	2 106	0	−3 873	−1 407
	3	1	736	−178	930	−221	−1 878	−1 177
		2	1 550	0	2 016	0	−3 729	−1 371
	4	1	745	−188	937	−229	−1 841	−1 149
		2	1 556	0	2 026	0	−3 744	−1 315
		3	1 494	0	1 930	0	−3 590	−1 216
6.0	1	1	762	−129	982	−167	−2 829	2 273
	2	1	699	−111	888	−138	−2 124	−1 740
		2	1 650	0	2 151	0	−3 921	−1 838
	3	1	716	−120	908	−148	−2 049	−1 631
		2	1 570	0	2 038	0	−3 753	−1 726
	4	1	722	−125	912	−151	−1 975	−1 577
		2	1 579	0	2 053	0	−3 775	−1 639
		3	1 493	0	1 925	0	−3 587	−1 572

*On the foundation downward force positive, horizontal force to the left positive, clockwise moment positive. The most conservative values of forces from frames having 1 in 3, 1 in 4 and 1 in 5 roof slopes are presented.

†To obtain forces due to basic wind pressure of 100 and 150 kg/m² reduce the forces given in the table proportionately.

‡Refer to Fig. 1 for foundation location.

NOTE — Add 30 kg/m² to foundation forces to include the dead of A C sheeting and girts in wall claddings.

TABLE 71 FOUNDATION FORCES FOR STEEL PORTAL FRAMES

Span : 9 m | Spacing of Frame : 6.0 m | Type of Support : Fixed

Column Height	No. of Bays	Foundation Location†‡	Foundation Forces* Due To: Dead Load: Downward force	Dead Load: Horizontal force	Dead Load: Moment	Live Load: Downward force	Live Load: Horizontal force	Live Load: Moment	Wind Load† $p = 200$ kg/m²: Maximum moment combination: *Downward force*	Maximum moment combination: *Horizontal force*	Maximum moment combination: *Moment*	Maximum uplift combination: *Downward force*	Maximum uplift combination: *Moment*
(m)			(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)	(kg)	(kg.m)
4.5	1	1	1 084	−430	802	1 309	−528	925	−2 700	2 777	−3 628	—	—
	2	1	1 054	−444	900	1 249	−517	975	− 375	−1 661	1 599	−2 332	−1 516
		2	2 229	0	0	2 738	0	0	−1 911	−1 691	1 671	−5 056	0
	3	1	1 080	−492	1 045	1 276	−568	1 122	− 412	−1 617	1 492	−2 377	−1 759
		2	2 173	0	139	2 651	0	100	898	−1 814	1 835	−4 913	− 167
	4	1	1 097	−529	1 158	1 292	−610	1 245	− 410	−1 618	1 491	−2 404	−1 964
		2	2 178	−101	296	2 658	− 86	264	869	−1 796	1 804	−4 925	− 439
		3	2 125	0	0	2 572	0	0	−1 170	−1 541	1 252	−4 783	0
6.0	1	1	1 084	−310	734	1 309	−374	839	−1 228	3 199	−5 258	−2 892	−5 063
		1	1 027	−301	765	1 218	−343	816	−1 445	−2 343	2 852	−2 375	−3 805
		2	2 283	0	0	2 800	0	0	−1 938	−2 233	2 787	−5 135	0
	3	1	1 053	−334	884	1 245	−375	925	−1 541	−2 225	2 428	−2 334	−1 291
		2	2 200	0	0	2 683	0	0	906	−2 233	2 634	−4 956	− 57
	4	1	1 067	−359	981	1 256	−398	1 014	− 341	−2 176	2 240	−2 353	−1 434
		2	2 208	0	209	2 695	0	151	866	−2 160	2 407	−4 974	− 253
		3	2 125	0	0	2 571	0	0	−1 149	−2 005	1 987	−4 786	0

*On the foundation downward force positive, horizontal force to the left positive, clockwise moment positive.
The most conservative values of forces from frames having 1 in 3, 1 in 4 and 1 in 5 roof slopes are presented.

†To obtain forces due to basic wind pressure of 100 and 150 kg/m² reduce the forces given in the table proportionately.

‡Refer to Fig. 1 for foundation location.

NOTE — Add 30 kg/m² to foundation forces to include the dead of A.C. sheeting and girts in wall claddings.

TABLE 72 FOUNDATION FORCES FOR STEEL PORTAL FRAMES

Span : 9 m Spacing of Frame : 6.0 m Type of Support : Hinged

Column Height	No. of Bays	Foundation Location‡	Foundation Forces* Due To: Dead Load		Live Load		Wind Load† p = 200 kg/m	
			Downward force (kg)	Horizontal force (kg)	Downward force (kg)	Horizontal force (kg)	Downward force (kg)	Horizontal force (kg)
(m)								
4.5	1	1	1 084	−256	1 309	−315	−3 198	−1 775
	2	1	1 023	−236	1 214	−277	−2 536	−1 664
		2	2 292	0	2 808	0	−5 165	−1 877
	3	1	1 047	−254	1 239	−295	−2 504	−1 568
		2	2 206	0	2 688	0	−4 972	−1 828
	4	1	1 061	−267	1 250	−306	−2 455	−1 532
		2	2 213	0	2 701	0	−4 992	−1 753
		3	2 126	0	2 573	0	−4 787	−1 622
6.0	1	1	1 084	−183	1 309	−222	−3 772	3 031
	2	1	995	−158	1 184	−184	−2 833	−2 320
		2	2 348	0	2 869	0	−5 228	−2 451
	3	1	1 019	−171	1 211	−197	−2 732	−2 174
		2	2 234	0	2 717	0	−5 004	−2 301
	4	1	1 028	−178	1 216	−202	−2 633	−2 103
		2	2 247	0	2 737	0	−5 080	−2 185
		3	2 125	0	2 567	0	−4 783	−2 096

*On the foundation downward force positive, horizontal force to the left positive, clockwise moment positive. The most conservative values of forces from frames having 1 in 3, 1 in 4 and 1 in 5 roof slopes are presented.

†To obtain forces due to basic wind pressure of 100 and 150 kg/m² reduce the forces given in the table proportionately.

‡Refer to Fig. 1 for foundation location.

NOTE — Add 30 kg/m² to foundation forces to include the dead of A C sheeting and girts in wall claddings.

TABLE 73 FOUNDATION FORCES FOR STEEL PORTAL FRAMES

Span : 12 m | Spacing of Frame : 4.5 m | Type of Support : Fixed

Column Height	No. of Bays	Foundation Location‡	Foundation Forces* Due To: Dead Load: Downward force	Dead Load: Horizontal force	Dead Load: Moment	Live Load: Downward force	Live Load: Horizontal force	Live Load: Moment	Wind Load† $p = 200$ kg/m²: Maximum moment combination: *Downward force*	Maximum moment combination: *Horizontal force*	Maximum moment combination: *Moment*	Maximum uplift combination: *Downward force*	Maximum uplift combination: *Moment*
(m)		(kg)	(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)	(kg)	(kg.m)
4.5	1	1	1 045	−559	1 109	1 309	−732	1 354	−2 600	2 652	−3 844	—	—
	2	1	1 037	−605	1 317	1 278	−761	1 541	−453	−1 219	1 257	−2 377	−2 553
		2	2 104	0	0	2 681	0	0	−1 876	−1 293	1 369	−4 967	0
	3	1	1 062	−668	1 523	1 307	−844	1 798	−459	−1 235	1 335	−2 423	−2 988
		2	2 072	−77	248	2 621	−72	250	890	−1 551	1 872	−4 864	−421
	4	1	1 077	−711	1 664	1 327	−910	2 007	−448	−1 266	1 438	−2 451	−3 041
		2	2 077	−152	457	2 625	−176	530	872	−1 588	1 994	−4 872	−895
		3	2 048	0	0	2 569	0	0	−1 192	−1 198	1 088	−4 777	0
6.0	1	1	1 045	−414	1 032	1 309	−528	1 236	−2 700	2 779	−4 844	—	—
	2	1	1 016	−428	1 160	1 249	−517	1 305	−375	−1 661	2 131	−2 333	−2 035
		2	2 147	0	0	2 738	0	0	−1 909	−1 693	2 230	−5 055	0
	3	1	1 041	−476	1 349	1 276	−570	1 504	−412	−1 617	1 987	−2 378	−2 368
		2	2 093	0	181	2 651	0	137	899	−1 814	2 447	−4 912	232
	4	1	1 057	−511	1 497	1 293	−613	1 674	−410	−1 618	1 986	−2 406	−2 662
		2	2 098	−99	387	2 658	−88	361	869	−1 796	2 407	−4 923	−606
		3	2 047	0	0	2 571	0	0	−1 169	−1 541	1 670	−4 782	0
9.0	1	1	1 045	−260	905	1 309	−323	1 074	−2 161	4 679	−11 019	−4 017	−10 593
	2	1	978	−245	913	1 205	−288	1 009	−1 828	−3 605	6 654	−3 096	−1 708
		2	2 222	0	0	2 827	0	0	−2 529	−3 340	6 138	−6 882	0
	3	1	1 003	−271	1 051	1 232	−314	1 139	−354	−3 803	5 210	−3 118	−2 016
		2	131	0	68	2 696	0	0	1 212	−3 276	5 556	−6 626	0
	4	1	1 015	−291	1 164	1 241	−332	1 240	−2 042	−3 335	5 175	−3 180	−2 290
		2	2 140	0	223	2 711	0	151	−1 153	−3 150	4 957	−6 655	350
		3	2 046	0	0	2 568	0	0	−1 520	−2 984	4 302	−6 380	0

*On the foundation downward force positive, horizontal force to the left positive, clockwise moment positive.

The most conservative values of forces from frames having 1 in 3, 1 in 4 and 1 in 5 roof slopes are presented.

†To obtain forces due to basic wind pressure of 100 and 150 kg/m² reduce the forces given in the table proportionately.

‡Refer to Fig. 1 for foundation location.

NOTE — Add 30 kg/m² to foundation forces to include the dead load of AC sheeting and girts in wall claddings.

TABLE 74 FOUNDATION FORCES FOR STEEL PORTAL FRAMES

Span : 9 m   Spacing of Frame : 4.5 m   Type of Support : Hinged

COLUMN HEIGHT	NO. OF BAYS	FOUNDATION LOCATION‡	Foundation Forces* Due To: Dead Load		Live Load		Wind Load† p = 200 kg/m	
			Downward force	Horizontal force	Downward force	Horizontal force	Downward force	Horizontal force
(m)			(kg)	(kg)	(kg)	(kg)	(kg)	(kg)
4.5	1	1	1 045	−336	1 309	−437	−2 878	2 179
	2	1	1 011	−327	1 244	−406	−2 834	−1 227
		2	2 157	0	2 748	0	−5 080	−1 446
	3	1	1 036	−353	1 270	−433	−2 364	−1 173
		2	2 097	0	2 657	0	−4 926	−1 500
	4	1	1 054	−374	1 286	−454	−2 390	−1 162
		2	2 101	54	2 664	0	−4 938	−1 465
		3	2 046	0	2 573	0	−4 784	−1 268
6.0	1	1	1 045	−247	1 309	−315	−3 198	2 459
	2	1	985	−227	1 214	−277	−2 537	−1 664
		2	2 209	0	2 809	0	−5 165	−1 877
	3	1	1 009	−245	1 239	−295	−2 319	−1 569
		2	2 125	0	2 688	0	−4 791	−1 828
	4	1	1 022	−258	1 250	−306	−2 457	−1 532
		2	2 132	0	2 701	0	−4 992	−1 753
		3	2 048	0	2 572	0	−4 785	−1 622
9.0	1	1	1 045	−153	1 309	−191	−5 497	4 487
	2	1	947	−128	1 171	−154	−4 026	−3 527
		2	2 285	0	2 895	0	−6 994	−3 649
	3	1	971	−139	1 199	−165	−3 834	−3 303
		2	2 163	0	2 728	0	−6 631	−3 393
	4	1	977	−144	1 208	−169	−3 661	−3 190
		2	2 179	0	2 753	0	−6 728	−3 214
		3	2 044	0	2 562	0	−6 373	−3 111

*On the foundation downward force positive, horizontal force to the left positive, clockwise moment positive. The most conservative values of forces from frames having 1 in 3, 1 in 4 and 1 in 5 roof slopes are presented.

†To obtain forces due to basic wind pressure of 100 and 150 kg/m² reduce the forces given in the table proportionately.

‡Refer to Fig. 1 for foundation location.

NOTE — Add 30 kg/m² to foundation forces to include the dead of A C sheeting and girts in wall claddings.

TABLE 75 FOUNDATION FORCES FOR STEEL PORTAL FRAMES

Span : 12 m Spacing of Frame : 6.0 m Type of Support : Fixed

Column Height	No. of Bays	Foundation Location‡	Foundation Forces* Due To: Dead Load: Downward force	Dead Load: Horizontal force	Dead Load: Moment	Live Load: Downward force	Live Load: Horizontal force	Live Load: Moment	Wind Load† p = 200 kg/m²: Maximum moment combination: *Downward force*	*Horizontal force*	*Moment*	Maximum uplift combination: *Downward force*	*Moment*
(m)			(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)	(kg)	(kg.m)
4.5	1	1	1 484	− 793	1 575	1 746	− 976	1 806	−3 467	3 536	− 5 125	—	—
	2	1	1 473	− 859	1 872	1 704	−1 015	2 055	− 604	−1 626	1 676	−3 169	− 3 404
		2	2 988	0	0	3 574	0	0	−2 501	−1 724	1 826	−6 622	0
	3	1	1 508	− 949	2 163	1 742	−1 126	2 398	− 612	−1 646	1 780	−3 234	− 3 983
		2	2 943	− 109	352	3 494	− 96	333	1 186	−2 068	2 496	−6 486	− 561
	4	1	1 530	−1 009	2 363	1 769	−1 213	2 677	− 595	−1 688	1 917	−3 279	− 4 455
		2	2 951	− 215	649	3 500	− 235	707	1 163	−2 118	2 658	−6 497	− 1 194
		3	2 909	0	0	3 425	0	0	−1 589	−1 597	1 451	−6 369	0
6.0	1	1	1 484	− 588	1 466	1 746	− 704	1 648	−3 601	3 705	− 6 458	—	—
	2	1	1 443	− 608	1 648	1 665	− 690	1 740	− 499	−2 214	2 841	−3 110	− 2 713
		2	3 050	0	0	3 651	0	0	−2 546	−2 257	2 973	−6 740	0
	3	1	1 478	− 676	1 916	1 702	− 760	2 006	− 549	−2 156	2 649	−3 170	− 3 157
		2	2 973	− 57	257	3 535	0	182	1 199	−2 418	3 263	−6 550	− 309
	4	1	1 502	− 727	2 126	1 724	− 817	2 231	− 547	−2 157	2 648	−3 208	− 3 534
		2	2 980	− 141	550	3 544	− 118	481	1 160	−2 395	3 209	−6 564	− 808
		3	2 907	0	0	3 428	0	0	−1 559	−2 055	2 227	−6 376	0
9.0	1	1	1 434	− 369	1 286	1 746	− 431	14 319	−2 409	6 273	−15 135	−5 356	−14 124
	2	1	1 389	− 348	1 297	1 606	− 384	1 345	−2 438	−4 807	3 372	−4 334	−10 470
		2	3 156	0	0	3 769	0	0	−3 453	−4 453	8 184	−9 176	0
	3	1	1 424	− 385	1 494	1 642	− 419	1 518	−2 655	−4 557	7 536	−4 157	− 2 687
		2	3 027	0	97	3 594	0	0	1 615	−4 368	7 408	−8 834	− 62
	4	1	1 442	− 413	1 653	1 655	− 443	1 653	−2 723	−4 446	6 899	−4 192	− 3 015
		2	3 040	− 51	316	3 614	0	202	1 537	−4 199	6 609	−8 873	− 467
		3	2 907	0	0	3 425	0	0	−2 027	−3 979	5 736	−8 507	0

*On the foundation downward force positive, horizontal force to the left positive, clockwise moment positive.
The most conservative values of forces from frames having 1 in 3, 1 in 4 and 1 in 5 roof slopes are presented.

†To obtain forces due to basic wind pressure of 100 and 150 kg/m² reduce the forces given in the table proportionately.

‡Refer to Fig. 1 for foundation location.

NOTE — Add 30 kg/m² to foundation forces to include the dead load of AC sheeting and girts in wall claddings.

TABLE 76 FOUNDATION FORCES FOR STEEL PORTAL FRAMES

Span : 12 m — Spacing of Frame : 6.0 m — Type of Support : Hinged

Column Height (m)	No. of Bays	Foundation Location‡	Foundation Forces* Due To: Dead Load, Downward force (kg)	Dead Load, Horizontal force (kg)	Live Load, Downward force (kg)	Live Load, Horizontal force (kg)	Wind Load† $p = 200$ kg/m, Downward force (kg)	Wind Load† $p = 200$ kg/m, Horizontal force (kg)
4.5	1	1	1 484	−477	1 746	−583	−3 837	2 905
	2	1	1 436	−464	1 659	−541	−3 170	−1 636
		2	3 064	0	3 665	0	−6 773	−1 928
	3	1	1 472	−501	1 693	−578	−3 180	−1 564
		2	2 979	0	3 543	0	−6 568	−1 999
	4	1	1 497	−531	1 715	−605	−3 187	−1 550
		2	2 985	− 77	3 552	0	−6 584	−1 954
		3	2 906	0	3 430	0	−6 376	−1 691
6.0	1	1	1 484	−351	1 746	−421	−4 264	−2 367
	2	1	1 399	−322	1 618	−369	−3 382	−2 218
		2	3 137	0	3 745	0	−6 887	−2 502
	3	1	1 432	−348	1 652	−394	−3 341	−2 092
		2	3 019	0	3 584	0	−6 628	−2 437
	4	1	1 452	−366	1 666	−408	−3 276	−2 042
		2	3 029	0	3 601	0	−6 656	−2 338
		3	2 909	0	3 429	0	−6 380	−2 163
9.0	1	1	1 483	−217	1 746	−255	−7 329	5 753
	2	1	1 345	−182	1 561	−206	−5 368	−5 025
		2	3 245	0	3 860	0	−9 326	−4 866
	3	1	1 379	−197	1 599	−220	−5 112	−4 404
		2	3 072	0	3 638	0	−8 910	−4 524
	4	1	1 389	−204	1 604	−225	−4 882	−4 253
		2	3 095	0	3 670	0	−8 970	−4 285
		3	2 903	0	3 416	0	−8 498	−4 148

*On the foundation downward force positive, horizontal force to the left positive, clockwise moment positive. The most conservative values of forces from frames having 1 in 3, 1 in 4 and 1 in 5 roof slopes are presented.

†To obtain forces due to basic wind pressure of 100 and 150 kg/m² reduce the forces given in the table proportionately.

‡Refer to Fig. 1 for foundation location.

NOTE — Add 30 kg/m² to foundation forces to include the dead of A C sheeting and girts in wall claddings.

TABLE 77 FOUNDATION FORCES FOR STEEL PORTAL FRAMES

Span : 18 m — Spacing of Frame : 6.0 m — Type of Support : Fixed

Column Height	No. of Bays	Foundation Location‡	Foundation Forces* Due To: Dead Load			Live Load			Wind Load† $p = 200$ kg/m²				
									Maximum moment combination			Maximum uplift combination	
			Downward force	Horizontal force	Moment	Downward force	Horizontal force	Moment	*Downward force*	*Horizontal force*	*Moment*	*Downward force*	*Moment*
(m)			(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)	(kg)	(kg.m)
6.0	1	1	1 652	− 991	2 698	1 964	− 1 249	3 165	− 3 862	2 940	− 8 112	—	—
	2	1	1 652	− 1 088	3 258	1 933	− 1 329	3 706	− 710	− 544	2 305	− 3 592	− 6 234
		2	3 305	0	0	3 988	0	0	− 2 794	− 680	2 548	− 7 396	0
	3	1	1 689	− 1 196	3 744	1 970	− 1 478	4 342	− 706	− 602	2 622	− 3 668	− 7 321
		2	3 267	− 147	634	3 913	− 152	676	1 337	− 1 160	3 881	− 7 267	− 1 148
9.0	1	1	1 652	− 656	2 451	1 964	− 793	2 783	− 5 400	3 432	− 14 540	—	—
	2	1	1 606	− 677	2 756	1 874	− 777	2 941	− 749	− 1 194	6 389	− 4 700	− 6 256
		2	3 396	0	0	4 108	0	0	− 3 818	− 1 262	6 690	− 10 109	0
	3	1	1 647	− 751	3 208	1 915	− 857	3 394	− 824	− 1 106	5 957	− 4 795	− 7 326
		2	3 310	− 64	433	3 976	0	311	1 798	− 1 501	7 343	− 9 823	− 709
12.0	1	1	1 652	− 473	2 239	1 964	− 562	2 522	− 4 886	6 399	− 20 519	− 5 784	− 20 267
	2	1	1 565	− 458	2 336	1 827	− 514	2 452	− 2 891	− 4 682	11 374	− 4 751	− 15 248
		2	3 479	0	0	4 202	0	0	− 3 874	− 4 467	11 150	− 10 271	0
	3	1	1 604	− 509	2 703	1 867	− 563	2 786	− 3 085	− 4 443	9 661	− 4 727	− 14 020
		2	3 352	0	238	4 024	0	93	− 1 814	− 4 465	10 539	− 9 910	− 247

*On the foundation downward force positive, horizontal force to the left positive, clockwise moment positive. The most conservative values of forces from frames having 1 in 3, 1 in 4 and 1 in 5 roof slopes are presented.

†To obtain forces due to basic wind pressure of 100 and 150 kg/m² reduce the forces given in the table proportionately.

‡Refer to Fig. 1 for foundation location.

NOTE — Add 30 kg/m² to foundation forces to include the dead load of AC sheeting and girts in wall claddings.

TABLE 78 FOUNDATION FORCES FOR STEEL PORTAL FRAMES

Span : 18 m — Spacing of Frame : 4.5 m — Type of Support : Hinged

Column Height (m)	No. of Bays	Foundation Location‡	Foundation Forces* Due To: Dead Load — Downward force (kg)	Dead Load — Horizontal force (kg)	Live Load — Downward force (kg)	Live Load — Horizontal force (kg)	Wind Load† p = 200 kg/m — Downward force (kg)	Wind Load† p = 200 kg/m — Horizontal force (kg)
6.0	1	1	1 652	−598	1 964	−746	− 4 188	3 180
	2	1	1 615	−594	1 884	−707	− 3 521	−1 617
		2	3 379	0	4 086	0	− 7 445	−1 954
	3	1	1 657	−644	1 926	−757	− 3 579	−1 560
		2	3 299	0	3 966	0	− 7 356	−2 100
9.0	1	1	1 652	−391	1 964	−473	− 6 395	4 918
	2	1	1 557	−358	1 820	−415	− 507	−3 327
		2	3 494	0	4 215	0	−10 332	−3 754
	3	1	1 595	−387	1 859	−443	−5 013	−3 137
		2	3 361	0	4 032	0	−9 941	−3 656
12.0	1	1	1 652	−279	1 964	−334	− 7 544	6 063
	2	1	1 514	−240	1 774	−275	− 5 667	−4 638
		2	3 581	0	4 307	0	−10 464	−4 902
	3	1	1 552	−260	1 815	−294	−5 469	−4 345
		2	3 405	0	4 076	0	−10 008	−4 602

*On the foundation downward force positive, horizontal force to the left positive, clockwise moment positive. To most conservative values of forces from frames having 1 in 3, 1 in 4 and 1 in 5 roof slopes are presented.

†To obtain forces due to basic wind pressure of 100 and 150 kg/m² reduce the forces given in the table proportionately.

‡Refer to Fig. 1 for foundation location.

NOTE — Add 30 kg/m² to foundation forces to include the dead of A C sheeting and girts in wall claddings.

TABLE 79 FOUNDATION FORCES FOR STEEL PORTAL FRAMES

Span : 18 m | Spacing of Frame : 6.0 m | Type of Support : Fixed

Column Height	No. of Bays	Foundation Location‡	Foundation Forces* Due To: Dead Load			Live Load			Wind Load†, p = 200 kg/m²: Maximum moment combination			Maximum uplift combination	
			Downward force	Horizontal force	Moment	Downward force	Horizontal force	Moment	*Downward force*	*Horizontal force*	*Moment*	*Downward force*	*Moment*
(m)			(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)	(kg)	(kg.m)
6.0	1	1	2 339	−1 403	3 820	2 618	−1 665	4 220	−5 150	5 337	−10 816	—	—
	2	1	2 339	−1 541	4 614	2 578	−1 773	4 942	− 947	−2 143	3 074	− 4 789	− 8 318
		2	4 680	0	0	5 318	0	0	−3 726	−2 324	3 398	− 9 862	0
	3	1	2 391	−1 694	5 302	2 637	−1 971	5 789	− 942	−2 220	3 496	− 4 890	− 9 761
		2	4 226	− 208	898	5 218	− 203	901	1 773	−2 964	5 174	− 9 690	− 1 531
9.0	1	1	2 339	− 928	3 470	2 618	−1 057	3 711	−7 201	7 412	19 387	—	—
	2	1	2 275	− 959	3 903	2 498	−1 036	3 921	−1 000	−4 427	8 519	− 6 267	− 8 341
		2	4 808	0	0	5 477	0	0	−5 090	−4 515	8 920	−13 479	0
	3	1	2 332	−1 067	4 543	2 553	−1 142	4 525	−1 099	−4 311	7 942	− 6 343	− 9 513
		2	4 687	− 91	613	5 302	0	415	2 398	−4 837	9 791	−13 097	− 945
12.0	1	1	2 340	− 670	3 171	2 618	−1 749	3 363	−3 275	8 532	−28 041	− 7 713	−27 022
	2	1	2 216	− 650	3 308	2 435	− 686	3 270	−3 855	−6 243	15 165	− 6 335	−20 331
		2	4 926	0	0	5 603	0	0	−5 165	−5 956	14 867	−13 695	0
	3	1	2 271	− 721	3 828	2 489	− 751	3 715	−4 114	−5 924	12 881	− 6 303	−18 694
		2	4 747	0	337	5 366	0	124	−2 419	−5 954	14 053	−13 214	− 329

*On the foundation downward force positive, horizontal force to the left positive, clockwise moment positive.
The most conservative values of forces from frames having 1 in 3, 1 in 4 and 1 in 5 roof slopes are presented.

†To obtain forces due to basic wind pressure of 100 and 150 kg/m² reduce the forces given in the table proportionately.

‡Refer to Fig. 1 for foundation location.

NOTE — Add 30 kg/m² to foundation forces to include the dead load of AC sheeting and girts in wall claddings.

TABLE 80 FOUNDATION FORCES FOR STEEL PORTAL FRAMES

Span : 18 m   Spacing of Frame : 4.5 m   Type of Support : Hinged

Column Height	No. of Bays	Foundation Location‡	Foundation Forces* Due To					
			Dead Load		Live Load		Wind Load† $p = 200$ kg/m	
			Downward force	Horizontal force	Downward force	Horizontal force	Downward force	Horizontal force
(m)			(kg)	(kg)	(kg)	(kg)	(kg)	(kg)
6.0	1	1	2 339	−847	2 618	− 994	− 4 860	−2 304
	2	1	2 286	−841	2 512	− 943	− 4 679	−2 157
		2	4 785	0	5 448	0	−10 082	−2 606
	3	1	2 346	−911	2 567	−1 010	− 4 773	−2 080
		2	4 672	57	5 287	0	− 9 808	−2 800
9.0	1	1	2 339	−553	2 618	− 631	− 8 527	6 567
	2	1	2 205	−508	2 427	− 553	− 6 766	−4 435
		2	4 948	0	5 620	0	−13 776	−5 005
	3	1	2 259	−549	2 476	− 591	− 6 684	−4 183
		2	4 759	0	5 376	0	−13 255	−4 874
12.0	1	1	2 339	−395	2 618	− 445	−10 058	8 084
	2	1	2 144	−341	2 365	− 367	− 7 556	−6 185
		2	5 070	0	5 743	0	−13 953	−6 535
	3	1	2 197	−368	2 420	− 393	− 7 292	−5 793
		2	4 821	0	5 435	0	−13 344	−6 136

*On the foundation downward force positive, horizontal force to the left positive, clockwise moment positive. The most conservative values of forces from frames having 1 in 3, 1 in 4 and 1 in 5 roof slopes are presented.

†To obtain forces due to basic wind pressure of 100 and 150 kg/m^2 reduce the forces given in the table proportionately.

‡Refer to Fig. 1 for foundation location.

NOTE — Add 30 kg/m^2 to foundation forces to include the dead of A C sheeting and girts in wall claddings.

TABLE 81 FOUNDATION FORCES FOR STEEL PORTAL FRAMES

Span : 24 m

Type of Support : Fixed

Column Height	No. of Bays	Foundation Location‡	Foundation Forces* Due To: Dead Load: Downward force	Dead Load: Horizontal force	Dead Load: Moment	Live Load: Downward force	Live Load: Horizontal force	Live Load: Moment	Wind Load†, p = 200 kg/m²: Maximum moment combination: *Downward force*	Maximum moment combination: *Horizontal force*	Maximum moment combination: *Moment*	Maximum uplift combination: *Downward force*	Maximum uplift combination: *Moment*
(m)			(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)	(kg)	(kg.m)
Spacing of frame : 4.5 m													
9.0	1	1	2 317	−1 238	4 911	2 618	−1 462	5 407	−6 953	4 942	−20 468	—	—
	2	1	2 300	−1 399	5 828	2 556	−1 520	6 142	−1 207	−4 010	6 715	− 6 378	−13 692
		2	4 667	0	0	5 362	0	0	−5 005	−1 321	7 301	−13 248	0
12.0	1	1	2 317	− 918	4 573	2 618	−1 056	4 938	−7 201	4 573	−25 817	—	—
	2	1	2 253	− 948	5 137	2 498	−1 034	5 209	−6 095	3 590	20 299	− 6 266	−11 055
		2	4 762	0	0	5 477	0	0	−5 094	−1 679	11 888	−13 481	0
Spacing of frame : 6.0 m													
	1	1	3 271	−1 748	6 935	3 491	−1 949	7 209	−9 245	6 589	−27 291	0	0
	2	1	3 248	−1 891	8 229	3 407	−2 026	8 189	−1 609	5 347	8 953	− 8 448	−18 063
		2	6 589	0	0	7 150	0	0	−6 674	−1 762	9 734	−17 664	0
12.0	1	1	3 271	−1 297	6 457	3 491	−1 408	6 584	−9 601	6 098	−34 423	0	0
	2	1	3 180	−1 339	7 254	3 331	−1 379	6 946	−1 332	4 786	15 160	− 8 354	−14 739
		2	6 723	0	0	7 302	0	0	−6 792	−2 239	15 851	−17 974	0

*On the foundation downward force positive, horizontal force to the left positive, clockwise moment positive. The most conservative values of forces from frames having 1 in 3, 1 in 4 and 1 in 5 roof slopes are presented.

†To obtain forces due to basic wind pressure of 100 and 150 kg/m² reduce the forces given in the table proportionately.

‡Refer to Fig. 1 for foundation location.

Note — Add 30 kg/m² to foundation forces to include the dead load of AC sheeting and girts in wall claddings.

TABLE 82 FOUNDATION FORCES FOR STEEL PORTAL FRAMES

Span : 24 m Type of Support : Hinged

Column Height (m)	No. of Bays	Foundation Location‡	Foundation Forces[1] Due To: Dead Load — Downward force (kg)	Dead Load — Horizontal force (kg)	Live Load — Downward force (kg)	Live Load — Horizontal force (kg)	Wind Load† p = 200 kg/m — Downward force (kg)	Wind Load† p = 200 kg/m — Horizontal force (kg)
Spacing of frame : 4.5 m								
9.0	1	1	2 317	− 745	2 618	− 875	− 7 674	5 810
	2	1	2 242	− 724	2 488	− 812	− 6 231	−3 271
		2	4 783	0	5 497	0	−13 545	−3 856
12.0	1	1	2 317	− 548	2 618	− 631	8 527	6 556
	2	1	2 184	− 503	2 427	− 553	− 6 765	−4 380
		2	4 899	0	5 619	0	−13 775	−5 005
Spacing of frame : 6.0 m								
9.0	1	1	3 271	−1 052	3 491	−1 167	−10 232	7 747
	2	1	3 165	−1 023	3 317	−1 082	− 8 477	−4 361
		2	6 754	0	7 329	0	−18 061	−5 141
12.0	1	1	3 271	− 773	3 491	− 841	−11 370	8 742
	2	1	3 083	− 710	3 236	− 738	− 9 020	−5 915
		2	6 917	0	7 492	0	−18 367	−6 673

*On the foundation downward force positive, horizontal force to the left positive, clockwise moment positive. The most conservative values of forces from frames having 1 in 3, 1 in 4 and 1 in 5 roof slopes are presented.

†To obtain forces due to basic wind pressure of 100 and 150 kg/m² reduce the forces given in the table proportionately.

‡Refer to Fig. 1 for foundation location.

NOTE — Add 30 kg/m² to foundation forces to include the dead load of A C sheeting and girts in wall claddings.

TABLE 83 FOUNDATION FORCES FOR STEEL PORTAL FRAMES

Span : 30 m

Column Height	No. of Bays	Foundation Location‡	Foundation Forces* Due To										
			Dead Load			Live Load			Wind Load† p = 200 kg/m²				
									Maximum moment combination			Maximum uplift combination	
			Downward force	Horizontal force	Moment	Downward force	Horizontal force	Moment	*Downward force*	*Horizontal force*	*Moment*	*Downward force*	*Moment*
(m)			(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)	(kg)	(kg)	(kg.m)	(kg)	(kg.m)
Fixed Support		Spacing of frame : 4.5 m											
9.0	1	1	3 038	−2 006	8 394	3 273	−2 326	9 051	− 8 525	9 037	−28 644	—	—
12.0	1	1	3 038	−1 524	7 953	3 273	−1 704	8 302	8 724	8 868	−33 452	—	—
		Spacing of frame : 6.0 m											
9.0	1	1	4 279	−2 825	11 821	4 364	−3 101	12 068	−11 367	12 050	−30 192	—	—
12.0	1	1	4 279	−2 146	11 200	4 364	−2 271	11 069	−11 632	11 824	−44 602	—	—
Hinged Support		Spacing of frame : 4.5 m											
9.0	1	1	3 038	−1 218	—	3 273	−1 388	—	—	6 969	—	− 9 104	—
12.0	1	1	3 038	− 914	—	3 273	−1 019	—	—	7 416	×	− 9 780	—
		Spacing of frame : 6.0 m											
9.0	1	1	4 279	−1 715	—	4 364	−1 851	—	—	9 292	—	−12 139	—
12.0	1	1	4 279	−1 288	—	4 364	−1 358	—	—	9 888	—	−13 040	—

*On the foundation downward force positive, horizontal force to the left positive, clockwise moment positive.
The most conservative values of forces from frames having 1 in 3, 1 in 4 and 1 in 5 roof slopes are presented.

†To obtain forces due to basic wind pressure of 100 and 150 kg/m² reduce the forces given in the table proportionately.

‡Refer to Fig. 1 for foundation location.

NOTE — Add 30 kg/m² to foundation forces to include the dead load of AC sheeting and girts in wall claddings.

TABLE 84 WELDED CONNECTION DETAILS FOR PORTAL FRAMES

Section Depth	Haunch Stiffner		Crown Stiffner Thickness
	Weld size (mm)	Thickness (mm)	
(mm)			(mm)
200	8	16	6
225	8	16	6
250	8	16	8
275	8	16	8
300	8	16	8
325	8	16	8
350	8	16	8
400	8	16	8
450	6	18	8
500	6	18	8
550	6	18	8
600	6	18	8

Note 1 — Stiffners should fit within the depth of the respective section. The breadth of stiffner should be sufficient to extend up to the edge of the flange.

Note 2 — Use 5.0 mm size weld for crown stiffners.

Note 3 — For details refer Fig. 5 to 7.

TABLE 85 HAUNCH BOLTED CONNECTION DETAIL

Type	ISLB	ISMB	ISWB	ISHB	t	HSFG or High Tensile (IOK) Bolt Detail			
						No.	Dia (mm)	a (mm)	b (mm)
I	—	—	600	—	40	8	24	45	50
II	—	600	550,500	450,400	36	8	24	45	50
III	—	550	450,400,350	350,300	32	8	20	35	40
IV	600	500,450,400	300	—	28	8	20	35	40
V	550,500,450			200,250,225	25	8	20	35	40
VI	—	350,300,250	225,250	150	25	8	16	30	30
VII	400,350,325,300	225	200	—	22	8	16	30	30
VIII	275	—	—	—	20	8	16	30	30
IX	250,225	200	—	—	18	8	16	30	30

Note — Ref. Fig. 8 for details.

TABLE 86 CROWN BOLTED CONNECTION DETAIL

Type	ISLB	ISMB	ISWB	ISHB	t	HSFG or High Tensile (IOK) Bolt Detail			
						No.	Dia (mm)	a (mm)	b (mm)
I	—	—	600	—	28	8	20	35	40
II	—	600	550,500	450	20	8	16	30	30
III	600	550	—	400	18	8	16	30	30
IV	550,500,450	400,450,500	250,300,350, 400,450	250,300 300,350	16	8	16	30	30
V	—	350,300,250	—	—	25	4	16	30	30
VI	400,350,325,300	225	225,200	200	22	4	16	30	30
VII	275,250,225	200	—	150	18	4	16	30	30

Note — Ref. Fig. 10 for details.

TABLE 87 FIXED COLUMN BASE DETAILS

Type	Depth of Column Section (mm)				Slab Base Size (mm)				Anchor Bolts		Stiffener Size	
	ISLB	ISMB	ISWB	ISHB	*a*	*b*	*c*	*t*	dia (mm)	Total Number	Thickness (mm)	*h* (mm)
I	225	200		150								
	250	225	200		500	450	50	36	36	6	10	250
	275		225									
II	300	250	250	200								
	325	300	300	225	600	450	50	40	36	6	12	250
	350	350		250								
	400	400										
III	450	450	350	300								
	500	500	400	350	800	500	60	50	45	6	16	250
	550		450									
IV				400								
				450	850	550	60	50	50	6	14	250
V			500									
				550	900	650	60	45	50	6	12	250
VI	600	550										
		600			850	650	60	36	56	6	12	250
VII			600		850	700	60	36			12	250

NOTE 1 — Refer to Fig. 11 for column base details.

NOTE 2 — Use 8 mm fillet weld for connection between base plate/column/stiffeners.

NOTE 3 — Details valid for interior and exterior columns.

NOTE 4 — Length of anchor bolts is to be calculated as shown in design example in **6.8**.

TABLE 88 HINGED COLUMN BASE DETAILS

Depth of Column Section (mm)	Slab Base Size (mm)				Anchor Bolts	
	a	*b*	*c*	*t*	dia (mm)	Total Number
300	350	300	50	16	14	4
400	450	300	50	16	16	4
500	550	300	50	18	18	4
600	650	300	50	20	22	4

NOTE 1 — For details of columns not specified above use the details given for the next higher section in the above table.

NOTE 2 — Refer to Fig. 11 for hinged column base details.

NOTE 3 — Details valid for interior and exterior columns.

NOTE 4 — Length of anchor bolts is to be calculated as shown in design example in **6.8**.

ERRATA

SP:40(S&T)-1987 HANDBOOK ON STRUCTURES WITH STEEL PORTAL FRAMES (WITHOUT CRANES)

(*Page 14, clause 6.0, Note 1 and Note 2*) - Substitute '(*see* IS:875-1964)' *for* '(Ref 1)'.

(*Page 15, clause 6.1*) - Substitute "(*refer* steel Designers' Mannual - Fourth Edition, CONSTRADO, ELBS Publishers)" *for* '(Ref 9)'.

(*Page 116, Table 77*)-- Substitute 'Spacing of Frame:4.5 m' *for* 'Spacing of Frame:6.0 m' below the title.

(*Page 119, Table 80*) - Substitute 'Spacing of Frame : 6.0 m' *for* 'Spacing of Frame : 4.5 m' below the title.