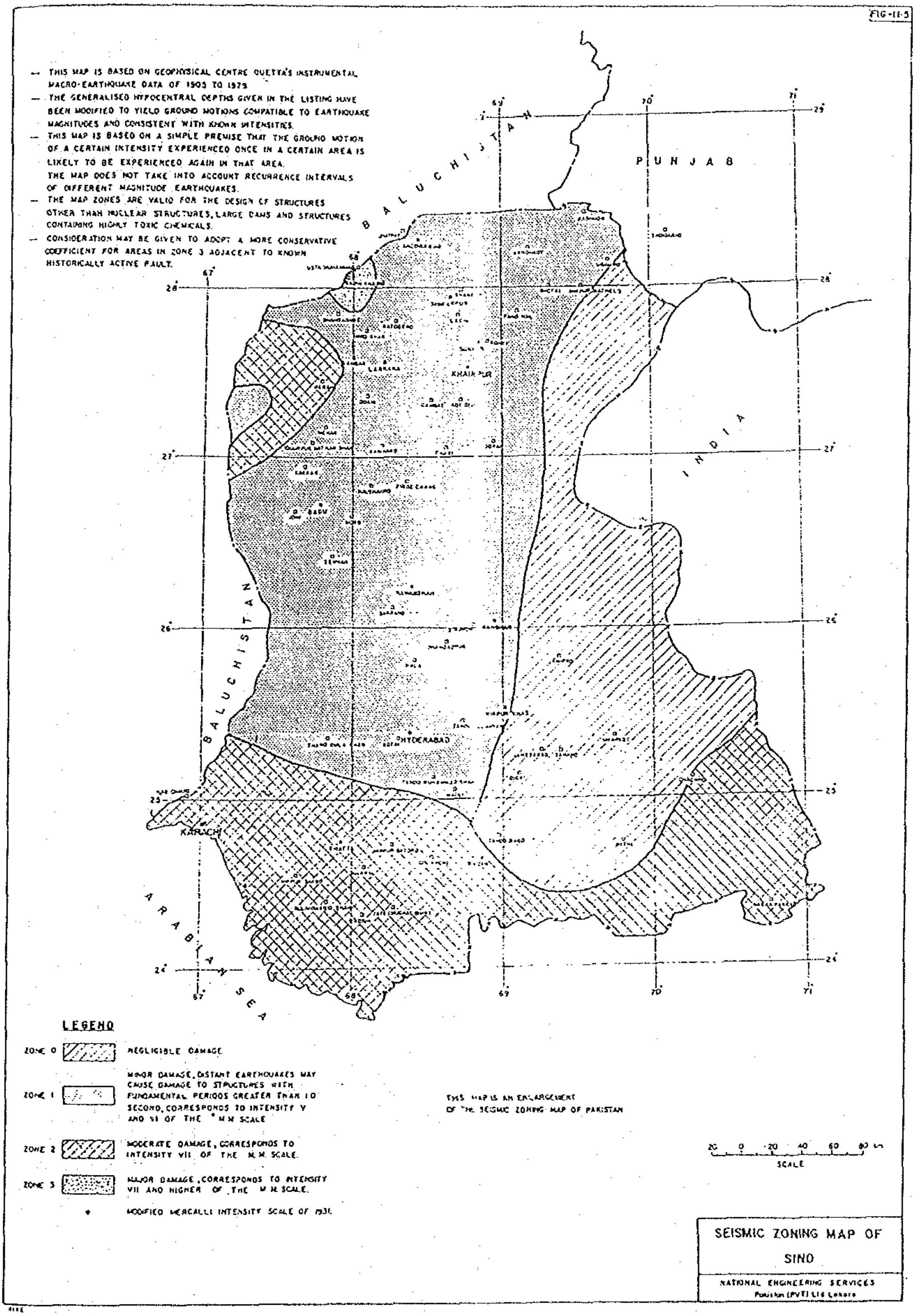


FIG-II-5
— THIS MAP IS BASED ON GEOPHYSICAL CENTRE QUETTA'S INSTRUMENTAL MACRO-EARTHQUAKE DATA OF 1905 TO 1979
— THE GENERALISED HYPOCENTRAL DEPTHS GIVEN IN THE LISTING HAVE BEEN MODIFIED TO YIELD GROUND MOTIONS COMPATIBLE TO EARTHQUAKE MAGNITUDES AND CONSISTENT WITH KNOWN INTENSITIES.
— THIS MAP IS BASED ON A SIMPLE PREMISE THAT THE GROUND MOTION OF A CERTAIN INTENSITY EXPERIENCED ONCE IN A CERTAIN AREA IS LIKELY TO BE EXPERIENCED AGAIN IN THAT AREA.
THE MAP DOES NOT TAKE INTO ACCOUNT RECURRENCE INTERVALS OF DIFFERENT MAGNITUDE EARTHQUAKES.
— THE MAP ZONES ARE VALID FOR THE DESIGN OF STRUCTURES OTHER THAN NUCLEAR STRUCTURES, LARGE DAMS AND STRUCTURES CONTAINING HIGHLY TOXIC CHEMICALS.
— CONSIDERATION MAY BE GIVEN TO ADOPT A MORE CONSERVATIVE COEFFICIENT FOR AREAS IN ZONE 3 ADJACENT TO KNOWN HISTORICALLY ACTIVE FAULT.
BALUCHISTAN
PUNJAB
INDIA
KHAIRPUR
HYDERABAD
KARACHI
ARABIAN SEA
LEGEND
ZONE 0 NEGLIGIBLE DAMAGE
ZONE 1 MINOR DAMAGE, DISTANT EARTHQUAKES MAY CAUSE DAMAGE TO STRUCTURES WITH FUNDAMENTAL PERIODS GREATER THAN 1.0 SECOND, CORRESPONDS TO INTENSITY V AND VI OF THE * M.M. SCALE
ZONE 2 MODERATE DAMAGE, CORRESPONDS TO INTENSITY VII OF THE M.M. SCALE.
ZONE 3 MAJOR DAMAGE, CORRESPONDS TO INTENSITY VII AND HIGHER OF THE M.M. SCALE.
* MODIFIED MERCALLI INTENSITY SCALE OF 1931.
THIS MAP IS AN ENLARGEMENT OF THE SEISMIC ZONING MAP OF PAKISTAN
SCALE
SEISMIC ZONING MAP OF SIND
NATIONAL ENGINEERING SERVICES Pakistan (PVT) Ltd Lahore

TABLE 11.15

HORIZONTAL FORCE FACTOR K FOR BUILDINGS OR OTHER STRUCTURES*1

Sr.No.	Type or Arrangement of Resisting Elements	Values of K
(1)	(2)	(3)
1.	All building framing systems except as hereinafter classified	1.00
2.	Building with a box system EXCEPTION:Buildings not more than three storeys in height with stud wall framing and using plywood horizontal diphragms and plywood vertical shear panels for the lateral force system may use K = 1.00.	1.33
3.	Buildings with a dual bracing system consisting of a ductile moment-resisting space frame and shear walls or braced frames using the following design criteria: (a) the frames and shear walls or braced frames shall resist the total lateral force in accordance with their relative rigidities considering the interaction of the shear walls and frames (b) the shear walls or braced frames acting independently of the ductile moment-resisting portions of the space frame shall resist the total required lateral forces (c) the ductile moment-resisting space frame shall have the capacity to resist not less than 25% of the required lateral force	0.80
4.	Buildings with a ductile moment-resisting space frame designed in accordance with the following criteria: The ductile moment resisting space frame shall have the capacity to resist the total required lateral force	0.67
5.	Elevated tanks plus full contents, on four or more cross-braced legs and not supported by a building	2.5 *2

Cont'd.......

TABLE 11.15 (Cont'd)

(1)	(2)	(3)
6.	Structures other than buildings and other than those setforth in Table 11.16.	2.0

*1 Where wind load would produce higher stresses, this load would be used in lieu of the loads resulting from earthquake forces.

*2 The minimum value of KC shall be 0.12 and the maximum value of KC need not exceed 0.25. The tower shall be designed for an accidental torsion of 5%. Elevated tanks which are supported by buildings or do not conform to type or arrangement of supporting elements as described above shall be designed using C_o=0.3.

TABLE 11.16

HORIZONTAL FORCE FACTOR Cp FOR ELEMENTS OF STRUCTURES AND NONSTRUCTURAL COMPONENTS

	Part or Portion of Buildings	Direction of Horizontal Forces	Value *1 of Cp
1.	Exterior bearing and nonbearing walls interior bearing walls and partitions, interior nonbearing walls and partitions. Masonry or concrete fences over 1.83 m (6 ft) high.	Normal to flat surface	*6 0.3
2.	Cantilever elements:		
	(a) parapets	Normal to flat surface	0.8
	(b) chimneys or stacks	Any direction	
3.	Exterior and interior ornamentations and appendages	Any direction	0.8
4.	When connected to, part of, or housed within a building:		*2*3 0.3
	(a) penthouses, anchorage and supports for chimneys, stacks and tanks, including contents		
	(b) storage racks with upper storage level at more than 2.44 m (8 ft) in height, plus contents	Any direction	
	(c) all equipment or machinery		
5.	Suspended ceiling framing systems	Any direction	*4 *7 0.3
6.	Connections for prefabricated structural elements other than walls, with force applied at centre of gravity of assembly.	Any direction	*5 0.3

*1 C_p for elements laterally self-supported only at the ground level may be two thirds of value shown.

*2 W_p for storage racks shall be the weight of the racks plus contents. The value of C_p for racks over two storage support levels in height shall be 0.24 for the level below the top two levels.

*3 For flexible and flexibly mounted equipment and machinery, the appropriate values of Cp shall be determined with consideration given to both the dynamic properties of the equipment and machinery and to the building or structure in which it is placed but shall be not less than the listed values.

*4 Ceiling weight shall include all light fixtures and other equipment which is laterally supported by the ceiling. For purpose of determining the lateral force, a ceiling weight of not less than 0.192 kN/sq.m (4 lbs/sq.ft) shall be used.

*5 The force shall be resisted by positive anchorage and not by friction.

*6 Interior walls, partitions which exceed 1.83 m (6 ft) in height shall be designed to resist all loads to which they are subjected but not less than a force of 0.24 kN/sq.m (5 lbs/sq.ft) applied perpendicular to the walls or partitions.

*7 Does not apply to ceilings constructed of lath and plaster or gypsum board screw or nail attached to suspended members that support a ceiling at one level extending from wall to wall.

11.5.3 Minimum Earthquake Forces for Structures

Every structure shall be designed and constructed to resist minimum total lateral seismic forces assumed to act nonconcurrently in the direction of each of the main axes of the structure in accordance with the following formula:

$$V = ZIKCSW \quad \text{.................................(a)}$$

The value of K shall be not less than that set forth in Table 11.15. The value of C and S are as indicated hereafter except that the product of CS need not exceed 0.14.

The value of C shall be determined in accordance with the following formula:

$$C = \frac{1}{15\sqrt{T}} \quad \text{..........................(b)}$$

The value of C need not exceed 0.12

The period T shall be established using the structural properties and deformational characteristics of the resisting elements in a properly substantiated analysis.

In the absence of a determination as indicated above, the value of T for buildings may be determined by the following formula:

$$T = \frac{0.09h_n}{\sqrt{D}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (c)$$

Where h_n and D are in metres

OR

$$T = \frac{0.05\ h_n}{\sqrt{D}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (c)$$

Where h_n and D are in feet.

Or in buildings in which the lateral force-resisting system consists of ductile moment-resisting space frames capable of resisting 100 percent of the required lateral forces and such system is not enclosed by or adjoined by more rigid elements tending to prevent the frame from resisting lateral forces:

$$T = 0.10N \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (d)$$

The value of S shall be determined by the following formulae, but shall be not less than 1.0:

$$\text{for } T/T_s = 1.0 \text{ or less } S = 1.0 + \frac{T}{T_s} - 0.5\left[\frac{T}{T_s}\right]^2 \ldots\ldots\ldots\ldots (e)$$

$$\text{for } T/T_s \text{ greater than } 1.0 \text{ or less } S = 1.2 + 0.6\frac{T}{T_s} - 0.3\left[\frac{T}{T_s}\right]^2 \ldots\ldots (f)$$

WHERE:

T in Formulae (e) and (f) shall be established by a properly substantiated analysis but T shall be not less than 0.3 second.

When T_s is not properly established, the value of S shall be 1.5.

EXCEPTION: Where T has been established by a properly substantiated analysis and exceeds 2.5 seconds, the value of S may be determined by assuming a value of 2.5 seconds for T_s.

11.5.4 Distribution of Lateral Forces

11.5.4.1 Structures having Regular Shapes or Framing Systems

The total lateral force V shall be distributed over the height of the structure in accordance with Formulas g, h and i.

$$V = F_t + \sum_{i=1}^{n} F_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots (g)$$

The concentrated force at the top shall be determined according to the following formula:

$$F_t = 0.07TV \ldots\ldots\ldots\ldots\ldots\ldots (h)$$

Ft need not exceed 0.25V and may be considered as 0 where T is 0.7 second or less. The remaining portion of the total base shear V shall be distributed over the height of the structure including level n according to the following formula:

$$F_x = \frac{(V - F_t)\, w_x\, h_x}{\sum_{i=1}^{n} w_i h_i} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

At each level designated as x, the force Fx shall be applied over the area of the building in accordance with the mass distribution on that level.

11.5.4.2 Setbacks

Buildings having setbacks wherein the plan dimension of the tower in each direction is at least 75 percent of the corresponding plan dimension of the lower part may be considered as uniform buildings without setbacks, provided other irregularities as defined in this clause do not exist.

11.5.4.3 Structures having Irregular Shapes or Framing Systems

The distribution of the lateral forces in structures which have highly irregular shapes, large differences in lateral resistance or stiffness between adjacent stories, or other unusual structural features, shall be determined considering the dynamic characteristics of the structure.

11.5.4.4 Accidental Torsion

In addition to the horizontal torsional moments where the vertical resisting elements depend on diaphragm action for shear distribution at any level, the shear resisting elements shall be capable of resisting a torsional moment assumed to be equivalent to the storey shear acting with an eccentricity of not less than 5 percent of the maximum building dimension at that level.

11.5.5 Overturning

At any level the incremental changes of the design overturning moment, in the storey under consideration shall be distributed to the various resisting elements in the same proportion as the distribution of the shears in the resisting system. Where other vertical members are provided which are capable of partially resisting the overturning moments, a redistribution may be made to these members if framing members of sufficient strength and stiffness to transmit the required loads are provided.

Where a vertical resisting element is discontinuous, the overturning moment carried by the lowest storey of that element shall be carried down as loads to the foundation.

11.5.6 Lateral Force on Elements of Structures and Nonstructural Components

Parts or portions of structures, nonstructural components and their anchorage to the main structural system shall be designed for lateral forces in accordance with the following formula:

$$F_p = ZIC_pW_p \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (j)$$

The values of C_p are setforth in Table 11.16. The value of the I coefficient shall be the value used for the building.

EXCEPTIONS:

1. The value of I for entire connector assembly shall be 1.0.

2. The value of I for anchorage of machinery and equipment required for life safety systems shall be 1.5.

The distribution of these forces shall be according to the gravity loads pertaining thereto.

11.5.7 Alternate Determination and Distribution of Seismic Forces.

Nothing in this section shall be deemed to prohibit the submission of properly substantiated technical data for establishing the lateral forces and distribution by dynamic analyses. In such analyses the dynamic characteristics of the structure must be considered.

11.5.8 Essential Facilities

Essential facilities are those structures or buildings which must be safe and usable for emergency purposes after an earthquake in order to preserve the health and safety of the general public. Such facilities shall include but not be limited to:

1. hospitals and other medical facilities having surgery or emergency treatment areas.

2. fire and police stations.

3. municipal government disaster operation and communication centres deemed to be vital in emergencies.

The design and detailing of equipment which must remain in place and be functional following a major earthquake shall be based upon the requirements of subsection 11.5.6 and Table 11.16. In addition, their design and detailing shall consider effects induced by structure drifts of not less than (2.0/K) times the storey drift caused by required seismic forces nor less than the storey drift caused by wind.

11.6 MISCELLANEOUS LOADS

11.6.1 Temperature Loads

All structures and components thereof shall be designed to cater for the effects of temperature and its variation.

11.6.2 Soil and Hydrostatic Loads

11.6.2.1 Foundation

The foundation of a building shall:

(a) safely sustain and transmit to the ground the combined critical vertical and horizontal loads in such a manner as not to cause any detrimental settlement or other movement which would impair the stability of or cause damage to the whole or any part of the building or of any adjoining building or works.

(b) be taken down to such depth, or be so constructed, as to safeguard the building against damage by swelling, shrinkage, collapse upon wetting or freezing of the sub-soil.

(c) be capable of adequately resisting any attack by sulphates or any other deleterious matter present in subsoil or subsoil water in contact with the foundation.

11.6.2.2 The soil classification and design bearing capacity shall be shown on the plans, supported by a Soil Investigation Report signed by an Registered Geotechnical Engineer. The building official may exempt this requirement for buildings upto three storeys. The need for Soil Investigation Report is not anticipated for single residential buildings unless unusual conditions are met at the site.

11.6.2.3 Foundation walls which are basement walls, or similar vertical walls below grade, shall be designed and constructed to withstand the lateral pressure from adjacent soil. Equivalent fluid pressure shall be computed by analysis however where the equivalent fluid weight has not been determined by soil analysis, the equivalent fluid weight of well drained granular soils of average or high permeability shall be not less than 3.93 kN/cu.m (25 lbs/cu.ft). The equivalent fluid weight of soils containing a higher percentage of clay, fine silt or similar material, and of soils generally of low permeability or poorly drained soils, shall be not less than 6.28 kN/cu.m (40 lbs/cu.ft) and the equivalent fluid weight of soils not drained shall be not less than 9.83 kN/cu.m (62.4 lbs/cu.ft)).

11.6.2.4 Weight of water shall be taken as 9.83 kN/cu.m (62.4 lbs/cu.ft) for computing hydrostatic pressures.

11.6.3 Erection Loads

All loads required to be carried by the structure or any part of it due to placing or storage of construction material and erection equipment including all loads due to operation of such equipment shall be considered as erection loads. Proper provisions shall be made to take care of all stresses due to such loads.

TABLE 11.17

VALUES FOR OCCUPANCY IMPORTANCE FACTOR I

Type of Occupancy	I
Essential facilities*	1.5
Any building where the primary occupancy is for assembly use for more than 300 persons (in one room)	1.25
All others	1.00

*See clause 11.5.8 for definition and additional requirements for essential facilities.

P = the live load in kg per m²,

L = the effective span of the main girder, truss or arch in m, and

W = width of the footway in m.

209.5. Each part of the footway shall be capable of carrying a wheel load of 4 tonnes, which shall be deemed to include impact, distributed over a contact area 300 mm in diameter; the permissible working stresses shall be increased by 25 per cent to meet this provision. This provision need not be made where vehicles cannot mount the footway as in the case of a footway separated from the roadway by means of an insurmountable obstacle, such as truss or a main girder.

Note: A footway kerb shall be considered mountable by vehicles.

209.6. The railings and parapets shall be designed to resist a lateral horizontal force and a vertical force each of 150 kg per metre applied simultaneously at the top of the railing or parapet. These forces need not be considered in the design of the main structural members if footpaths are provided. In cases where footpaths are provided, the effect of these forces shall be considered in the design of the structural system supporting the railings and the footpath upto the face of the footpath kerb only.

210. TRAMWAY LOADING

210.1. When a road bridge carries tram lines, the live load due to the type of tram cars sketched in Fig. 4 shall be computed and shall be considered to occupy a 3 m width of roadway.

210.2. A nose to tail sequence of the tram cars or any other sequence which produces the heaviest stresses shall be considered in the design.

210.3. Stresses shall be calculated for the following two conditions and the maximum thereof considered in the design:

(a) Tram loading, followed and preceded by the appropriate standard loading specified in Clause 207.1 together with that standard loading on the traffic lanes not occupied by the tram car lines.

(b) The appropriate standard loading specified in Clause 207.1 without any tram cars.

211. IMPACT

211.1. Provision for impact or dynamic action shall be made by an increment of the live load by an impact allowance expressed as a fraction or a percentage of the applied live load.

211.2. **For Class A or Class B Loading:**—In the members of any bridge designed either for Class A or Class B loading (vide Clause 207.1), this impact percentage shall be determined from the curves indicated in Fig. 5. The impact fraction shall be determined from the following equations which are applicable for spans between 3 m and 45 m.

(i) Impact factor fraction for reinforced concrete bridges $= \dfrac{4.5}{6+L}$

(ii) Impact factor fraction for steel bridges $= \dfrac{9}{13.5+L}$

For spans simply supported or continuous or for arches—the 'L' shall be the effective span of the member under consideration.

211.3. **For Class AA Loading and Class 70 R Loading :**—The value of the impact percentage shall be taken as follows:

(a) For spans less than 9 m :

(i) For tracked vehicles : 25 per cent for spans upto 5 m linearly reducing to 10 per cent for spans of 9 m

(ii) For wheeled vehicles : 25 per cent.

(b) For spans of 9 m or more:

(i) Reinforced concrete bridges

Tracked vehicles : 10 per cent upto a span of 40 m and in accordance with the curve in Fig. 5 for spans in excess of 40 m.

Wheeled vehicles : 25 per cent for spans upto 12 m and in accordance with the curve in Fig. 5 for spans in excess of 12 m

(ii) Steel bridges

Tracked vehicles : 10 per cent for all spans

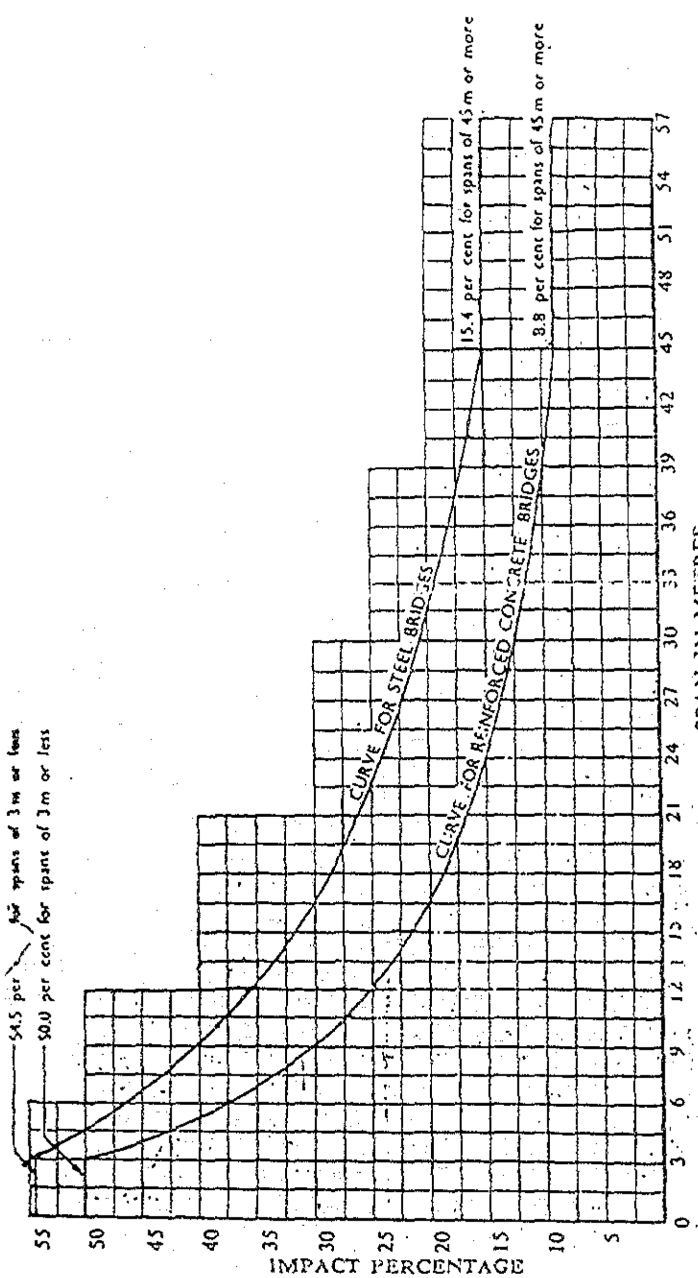


Fig. 5. Impact percentage curves for highway bridges for Class A and Class B loadings (Clause 211.3)

than 450 kg per linear metre in the plane of the loaded chord and 225 kg per linear metre in the plane of unloaded chord on through or half-through truss, latticed or other similar spans, and not less than 450 kg per linear metre on deck spans.

212.7. A wind pressure of 240 kg per m² on the unloaded structure, applied as specified in Clauses 212.2 and 212.3 shall be used if it produces greater stresses than those produced by the combined wind forces as per Clauses 212.2, 212.3, 212.4 and 212.5 or by the wind force as per Clause 212.6.

212.8. In calculating the uplift in the posts and anchorages of high latticed towers due to the above mentioned lateral forces, stresses shall also be investigated for the condition of decking being loaded on a traffic lane or lanes on the leeward side only.

213. HORIZONTAL FORCES DUE TO WATER CURRENTS

213.1. Any part of a road bridge which may be submerged in running water shall be designed to sustain safely the horizontal pressure due to the force of the current.

213.2. On piers parallel to the direction of the water current, the intensity of pressure shall be calculated from the following equation :

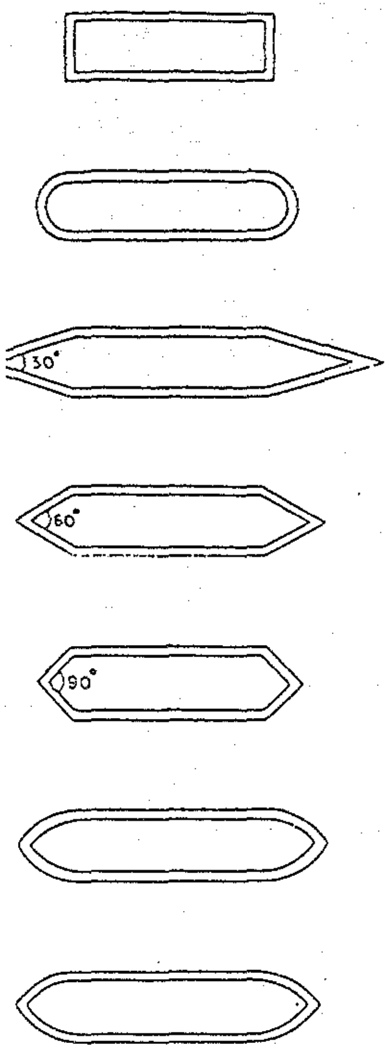
$$P = 52\ KV^2$$

where P = intensity of pressure due to the water current, in kg per sq. m.

V = the velocity of the current at the point where the pressure intensity is being calculated, in metres per second; and

K = a constant having the following values for different shapes of piers illustrated in Fig. 7 :

(i) Square ended piers (and for the superstructure):	1.50
(ii) Circular piers or piers with semi-circular ends;	0.66
(iii) Piers with triangular cut and ease waters, the angle included between the faces being 30 degrees or less :	0.50
(iv) Piers with triangular cut and ease waters, the angle included between the faces being more than 30 degrees but less than 60 degrees .	0.50 to 0.70
(v) —do—60 to 90 degrees :	0.70 to 0.90



Piers with square ends

Circular piers or piers with semi-circular ends

Piers with triangular cut and ease waters, the angle included between the faces being 30 degrees or less

Piers with triangular cut and ease waters, the angle included between the faces being more than 30 degrees but less than 60 degrees

Piers with triangular cut and ease waters, the angle included between the faces being 60 to 90 degrees

Piers with cut and ease waters of equilateral arcs of circles

Piers with arcs of the cut and ease waters intersecting at 90 degrees

Fig. 7

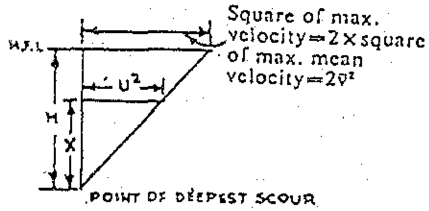
APES OF BRIDGE PIERS

Clause (213.2)

(vi) Piers with cut and ease waters of equilateral arcs of circles : 0.45

(vii) Piers with arcs of the cut and ease waters intersecting at 90 degrees : 0.50

213.3. The value of V^2 in the equation given in Clause 213.2 shall be assumed to vary linearly from zero at the point of deepest scour to the square of the maximum velocity at the free surface of water. The maximum velocity for the purpose of this sub-clause shall be assumed to be $\sqrt{2}$ times the maximum mean velocity of the current.



Square of velocity at a height X from the point of deepest

$$\text{scour} = U^2 = 2\,\frac{\bar{V}^2 X}{H}$$

where $\bar{V}$ is the maximum mean velocity.

213.4. When the current strikes the pier at an angle, the velocity of the current shall be resolved into two components—one parallel and the other normal to the pier.

(a) The pressure parallel to the pier shall be determined as indicated in Clause 213.2 taking the velocity as the component of the velocity of the current in a direction parallel to the pier.

(b) The pressure of the current, normal to the pier and acting on the area of the side elevation of the pier, shall be calculated similarly taking the velocity as the component of the velocity of the current in a direction normal to the pier, and the constant K as 1.5, except in the case of circular piers where the constant shall be taken as 0.66.

213.5. To provide against possible variation of the direction of the current from the direction assumed in the design, allowance shall be made in the design of piers for an extra variation in the current direction of 20 degrees; that is to say, piers intended to be parallel to the direction of current shall be designed for a variation of 20 degrees from the normal direction of the current and piers originally intended to be inclined at θ degrees to the direction of the current shall be designed for a current direction inclined at $(20 \pm \theta)$ degrees to the length of the pier.

length of the bridge, and to occupy any position which will produce maximum stresses provided that the minimum clearances between a vehicle and the roadway face of kerb and between two passing or crossing vehicles, shown in Figs. 1 to 3, are not encroached upon.

207.1.3. For each standard vehicle or train, all the axles of a unit of vehicles shall be considered as acting simultaneously in a position causing maximum stresses.

207.1.4. Vehicles in adjacent lanes shall be taken as headed in the direction producing maximum stresses.

207.1.5. The spaces on the carriageway left uncovered by the standard train of vehicles shall not be assumed as subject to any additional live load.

*207.2. DELETED

207.3. Dispersion of Load through Fills on Arch Bridges.

The dispersion of loads through the fills above the arch shall be assumed at 45 degrees both along and perpendicular to the span in the case of arch bridges.

208. REDUCTION IN THE INTENSITY OF LIVE LOAD STRESSES ON BRIDGES ACCOMMODATING MORE THAN TWO TRAFFIC LANES

208.1. The position and number of loaded lanes used shall be such as to produce maximum stresses in all cases.

208.2. Where maximum stresses are produced in any member by simultaneously loading more than two traffic lanes, the intensities of the resultant live load stresses shall be reduced by 10 per cent for each additional loaded traffic lane in excess of the two lanes subject to a maximum reduction of 20 per cent, and subject also to the condition that the stresses as thus reduced are not lower than the stresses resulting from a simultaneous loading on two traffic lanes.

*Deleted, as relevant provisions are covered in IRC : 21-1972 Standard Specifications and Code of Practice for Road Bridges—Section III.

209. FOOTWAY, KERB, RAILINGS AND PARAPET LOADING - (the provisions under this Clause do not apply to Foot-Bridges)

209.1. For all parts of bridge floors accessible only to pedestrians and animals and for all footways the loading shall be 400 kg per m². Where crowd loads are likely to occur, such as on bridges located near towns, which are either centres of pilgrimage or where large congregational fairs are held seasonally, the intensity of footway loading shall be increased from 400 kg per m² to 500 kg per m².

209.2. Kerbs, 0.6 m or more in width, shall be designed for the above loads and for a local lateral force of 750 kg per metre, applied horizontally at the top of the kerb. If the kerb width is less than 0.6 m, no live load shall be applied in addition to the lateral load specified above.

Note: The horizontal force need not be considered in the design of the main structural members of the bridge.

209.3. In calculating stresses in members of structures with cantilevered footways, the footways shall be considered as loaded on one side or on both sides, or unloaded, whichever condition gives the maximum stresses.

209.4. In bridges designed for any of the loadings described in Clause 207.1, the main girders, trusses, arches, or other members supporting the footways shall be designed for the following live loads per square metre of footway area, the loaded length of footway taken in each case being such as to produce the worst effects on the member under consideration:

(a) For effective span of 7.5 m or less, 400 kg per m² or 500 kg per m² as the case may be, based on sub-clause 209.1

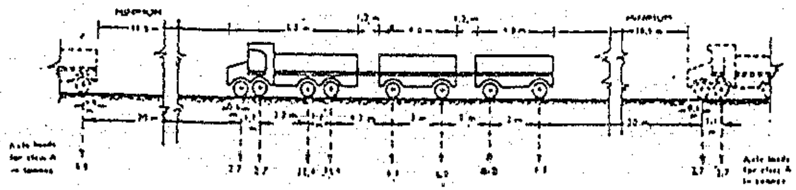
(b) For effective spans of over 7.5 m but not exceeding 30 m, the intensity of load shall be determined according to the equation :

$$P = P' - \left(\frac{40L - 300}{9}\right)$$

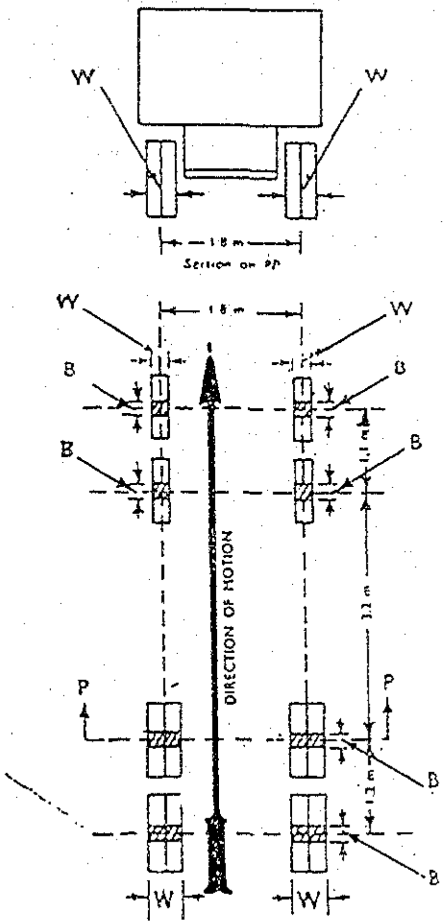
(c) For effective spans of over 30 m, the intensity of load shall be determined according to the equation:

$$P = \left(P' - 260 + \frac{4800}{L}\right)\left(\frac{16.5 - W}{15}\right)$$

where $P' = 400$ kg per m² or 500 kg per m² as the case may be, based on sub-clause 209.1,



Class A train of vehicles



Plan
Driving vehicle
Fig. 2
Class 'A' train of vehicles
(Clause 207.1)

Notes:

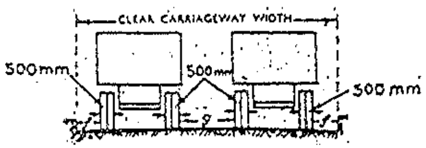
The nose to tail distance between successive trains shall not be less than 18.4 m.

2. No other live load shall cover any part of the carriageway when a train of vehicles (or trains of vehicles in multi-lane bridge) is crossing the bridge.

3. The ground contact area of the wheels shall be as under:

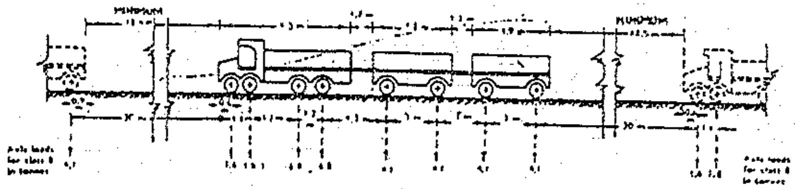
Axle load	Ground contact area	
tonnes	B mm	W mm
11.4	250	500
6.8	200	380
2.7	150	200

4. The minimum clearance, *f*, between outer edge of the wheel and the roadway face of the kerb, and the minimum clearance, *g*, between the outer edges of passing or crossing vehicles on multi-lane bridges shall be as given below:

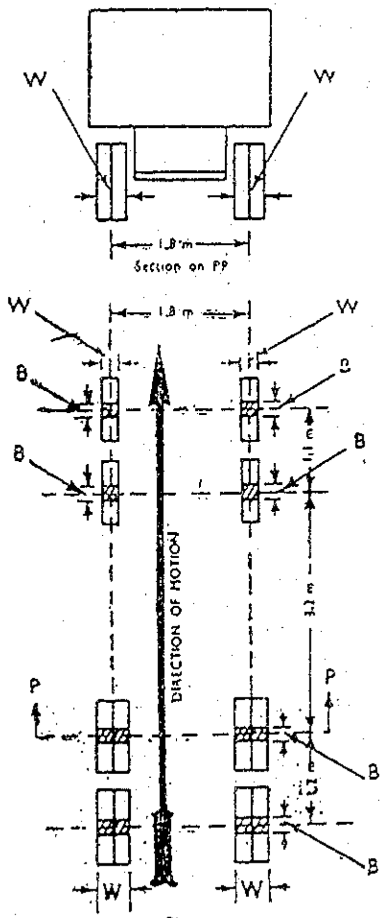


Clear carriageway width	*g*	*f*
5.5 m to 7.5 m	Uniformly increasing from 0.4 m to 1.2 m	150 mm for all carriage-way widths
Above 7.5 m	1.2 m	

IRC : 6-1966



Class B train of vehicles



Plan
Driving vehicle
Fig. 3
Class 'B' train of vehicles
(Clause 207.1)

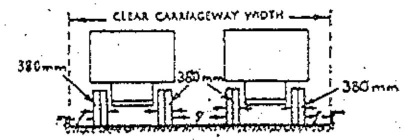
Notes:

1. The nose to tail distance between successive trains shall not be less than 18.4 m.

2. No other live load shall cover any part of the carriageway when a train of vehicles (or trains of vehicles in multi-lane bridge) is crossing the bridge.

3. The ground contact area of the wheels shall be as under:

Axle load	Ground contact area	
tonnes	B mm	W mm
6.8	200	380
4.1	150	300
1.6	125	175



4. The minimum clearance, *f*, between outer edge of the wheel and the roadway face of the kerb, and the minimum clearance, *g*, between the outer edges of passing or crossing vehicles on multi-lane bridges shall be as given below:

Clear carriageway width	*g*	*f*
5.5 m to 7.5 m	Uniformly increasing from 0.4 to 1.2 m	150 mm for all carriage-way widths
Above 7.5 m	1.2 m	

Materials		Weight per cu.m. in tonnes
23. Stone masonry (lime mortar)	...	2.4
24. Water	...	1.0
25. Wood	...	0.8
26. Cast iron	...	7.2
27. Wrought iron	...	7.7
28. Steel (rolled or cast)	...	7.8

206. TRAFFIC LANES

The number of traffic lanes on a bridge shall be determined by the maximum integral number of trains of standard Class A vehicles described in Clause 207, which can be accommodated on the clear carriageway width of the bridge, with the vehicles travelling parallel to the length of the bridge and leaving the minimum clearances specified in Clause 207.

All new bridges shall be of either one-lane, two-lane, or four-lane width. Three-lane bridges shall not be constructed. In the case of four-lane or multiples of two-lane bridges, at least 1.2m wide central verge shall be provided.

207. LIVE LOADS

207.1 **Details of I.R.C. Loadings**

207.1.1. For bridges classified under Clause 201.1, the designed live load shall consist of standard wheeled or tracked vehicles or trains of vehicles as illustrated in Figs. 1 to 3 and Appendix I. The trailers attached to the driving unit are not to be considered as detachable.

207.1.2. Within the kerb to kerb width of the roadway, the standard vehicle or train shall be assumed to travel parallel to the

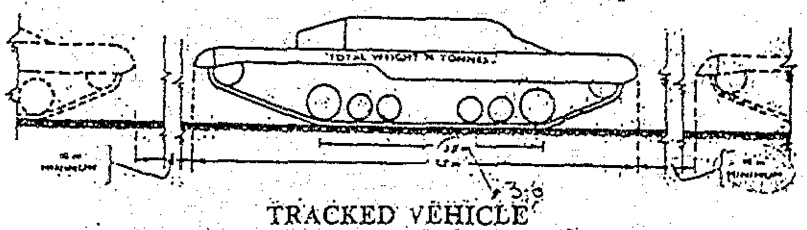
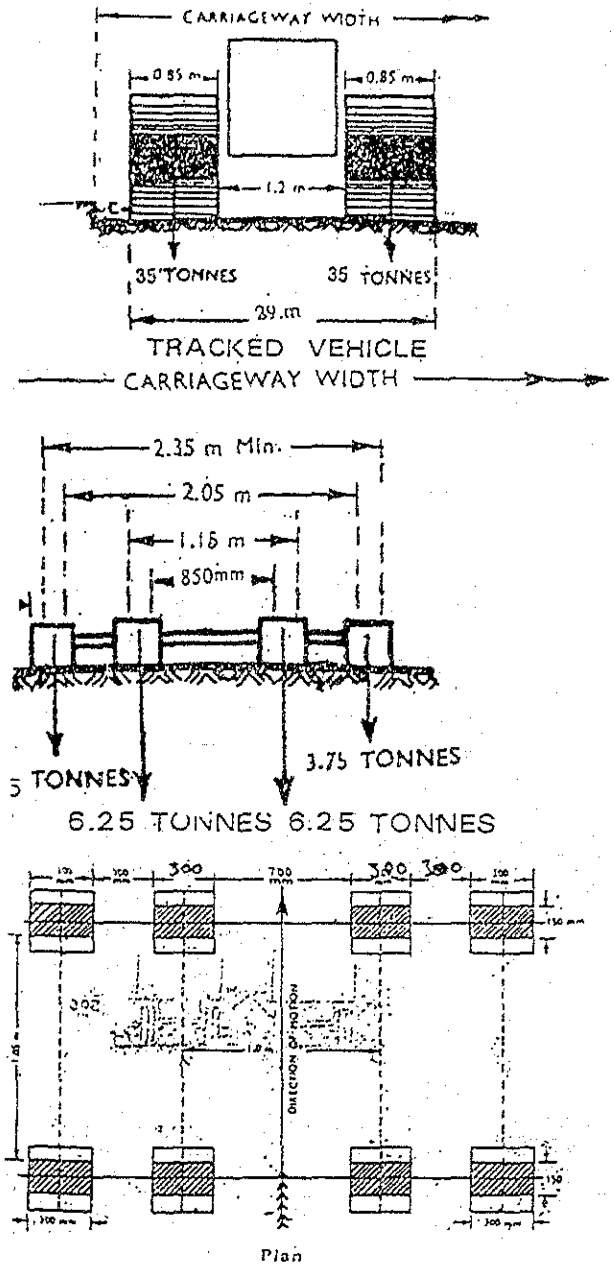


Fig 1. Class AA tracked and wheeled vehicles (Clause 207.1)

Fig. 1 (Contd.)



Notes :

1. The nose to tail spacing between two successive vehicles shall not be less than 90 m.

2. For multi-lane bridges and culverts, one train of Class AA tracked or wheeled vehicles whichever creates severer conditions shall be considered for every two traffic lane width. No other live load shall be considered on any part of the said 2-lane wide carriageway of the bridge when above mentioned train of vehicles is crossing the bridge.

3. The maximum loads for the wheeled vehicle shall be 20 tonnes for a single axle, or 40 tonnes for a bogie of two axles spaced not more than 1.2 m centres.

4. The minimum clearance between the road face of the kerb and the outer edge of the wheel or track, C, shall be as under :

Carriageway width	Minimum value of C
Single Lane Bridges	
3.8 m and above	0.3 m
Multi-Lane Bridges	
Less than 5.5 m	0.6 m
5.5 m or above	1.2 m

213.6. In case of a bridge having a pucca floor or having an inerodible bed, the effect of cross-currents shall in no case be taken as less then that of a static force due to a difference of head of 250 mm between the opposite faces of a pier.

213.7. When supports are made with two or more piles or trestle columns, the group shall be treated as a solid rectangular pier of the same overall length and width and the value of K taken as 1.25 for calculating pressures due to water currents both parallel and normal to the pier.

213.8. The effects of the force of water currents shall be duly considered upto the level indicated in Clause 214.7.

214. LONGITUDINAL FORCES

214.1. In all road bridges, provision shall be made for longitudinal forces arising from any one or more of the following causes.

(a) Tractive effort caused through acceleration of the driving wheels ;

(b) Braking effect resulting from the application of the brakes to braked wheels ; and

(c) Frictional resistance offered to the movement of free bearings due to change of temperature or any other cause.

Note : Braking effect is invariably greater than the tractive-effort.

214.2. The braking effect on a simply supported span or a continuous unit of spans or on any other type of bridge unit shall be assumed to have the following value :

(a) In the case of a single lane or a two-lane bridge : twenty per cent of the first train load plus ten per cent of the load of the succeeding trains or part thereof, the train loads in one lane only being considered for the purposes of this sub-clause. Where the entire first train is not on the full span, the braking force shall be taken as equal to twenty per cent of the loads actually on the span.

(b) In the case of bridges having more than two lanes: as in (a) above for the first two lanes plus five per cent of the loads on the lanes in excess of two.

Note : The loads in this Clause shall not be increased on account of impact.

214.3. The force due to braking effect shall be assumed to act along a line parallel to the roadway and 1.2 m above it. While transferring the force to the bearings, the change in the vertical reaction at the bearings should be taken into account.

214.4. The longitudinal force at any free bearing shall be limited to the sum of dead and live load reactions at the bearing multiplied by the appropriate co-efficient of friction. The co-efficient of friction at the bearing shall be assumed to have the following values.

For roller bearings	... 0.03
For sliding bearings of hard copper alloy	... 0.15
For sliding bearings of steel on cast iron or steel on steel	... 0.25
For sliding bearings of steel on ferro asbestos	... 0.20
For other types of bearings of proved utility if permitted at the discretion of the Engineer-in-charge	As may be permitted by the Engineer-in-charge on examination of the available data.

For simply supported reinforced concrete and prestressed concrete superstructure, the span upto which plate bearings can be used shall be limited to 15 metres.

214.5. The longitudinal force at the fixed bearing shall be taken as the algebraic sum of the longitudinal forces at the free bearings in the bridge unit under consideration and the force due to the braking effect on the wheels as mentioned in Clause 214.2.

214.6. The effects of braking force on bridge structures without bearings, such as arches, rigid frames, etc., shall be calculated in accordance with opproved methods of analysis of indeterminate structures.

214.7. The effects of the longitudinal forces and all other horizontal forces should be calculated upto a level where the resultant passive earth resistance of the soil below the deepest scour level (floor level in case of a bridge having pucca floor) balances these forces.

217.3. Where an adequately designed reinforced concrete approach slab covering the entire width of the roadway, with one end resting on the structure, designed to retain earth and extending for a length of not less than 3.5 m into the approach is provided, no live load surcharge need be considered in the design of that structure.

TABLE OF EQUIVALENT HEIGHTS OF SURCHARGE OF EARTH

Depth of abutment below the road level in metres	*H*, in metre, for the concentrated surface loads due to the wheel or track loads of the following I.R.C. Standard Loadings					
	I.R.C. CLASS AA AND CLASS 70 R LOADINGS		I.R.C. CLASS A LOADING		I.R.C. CLASS B LOADING	
	Single lane bridges	Multi-lane bridges	Single lane bridges	Multi-lane bridges	Single lane bridges	Multi-lane bridges
1	2	3	4	5	6	7
0.2	26.0	15.4	14.3	17.2	8.3	10.0
1.0	15.0	9.1	8.5	10.0	5.1	5.8
2.0	8.0	5.5	5.1	6.1	3.0	3.7
3.0	6.8	4.1	3.8	4.6	2.3	2.7
4.0	5.5	3.3	3.0	3.5	1.8	2.1
6.0	3.8	2.3	2.2	2.6	1.3	1.5
8.0	3.0	1.8	1.7	2.0	1.0	1.2
10.0 and above	2.6	1.5	1.4	1.7	0.9	1.0

Note : The above figures are based on the following values for the constants for the abutment and the backfill:

(1) Length of abutment (L)=4.5 m for single lane bridges and 7.6 m for multi-lane bridges.

(2) Angle of internal friction of the backfill (ϕ)=30°.

(3) Weight of backfill (W)...1600 kg per cu. m.

(4) The resultant earth pressure acts in a horizontal direction

For different values, say, L_1, ϕ_1 and W_1 for the constants, the figures given in the above Table should be multiplied by the following factors :

$$\frac{L\ (4.5 \text{ or } 7.6 \text{ as the case may be})}{L_1}\ ;\ \frac{(1+\sin\phi_1)}{3(1-\sin\phi_1)} \text{ and } \frac{1600}{W_1} \text{ respectively.}$$

付属資料－4　橋梁、道路建設に関するパキスタン国内企業の現状

橋梁、道路建設に対するパキスタン国内のコンサルタントおよびコントラクターの能力は設計・施工の両分野において、他の途上国に比較しかなり高く評価することができる。

橋梁プロジェクトの調査、測量、設計等に関するコンサルタントの技術力は従来ＢＳを基準にしたものが主体であるが、かなりしっかりしたものであり、また施工中の橋梁の品質も大型のものは、良く管理されている。支間50～60ｍのプレストレストコンクリート橋が国内施工会社の手で施工された実績もある。

ただし、国内企業には鋼構造物に対する設計・施工経験が乏しく、このため、鋼橋の設計・施工にあたっては、我が国の技術協力が必要であると考えられる。

パキスタン国内の主要な建設コンサルタント企業および建設会社を次に示す。

(1) 建設コンサルタント企業

1) A.A. Associates
   26-A, Sajjab Square, Shaheed-E-Millat Road, Karachi-8
2) Associated, Consultancy Centre
   1 Fl., Banqash Plaza, Markaz, F/7, Islamabad
3) Engineering Consultants
   29 Block 748, Dural Aman Housing Society, Shahra-E-Faisal, Karachi
4) Progressive Consultants
   25-D/1 Gulberg-Ⅲ, Lahore
5) Republic Engineering Corporation Ltd.
   76-B, 1 Gulberg-Ⅲ, Lahore
6) Zafar Associates
   P.O.Box 3167, Housing Society Pechs, Karachi-29
7) Nespak Ltd. (国営コンサルタント)
   417, Wapda House, P.O.Box 1351, Lahore

(2) 建設会社（橋梁建設に実績を持つもの）

1) Associated Construction Ltd.
2) Gammon (PAK) Ltd.
3) Interconstruct (PVT) Ltd.
4) Interhom Ltd.
5) Karron
6) MLC
7) Nazir and Co.,Ltd.

付属資料－５　ＮＷＦＰプロジェクトの計画、認可、実施の手順

ＮＷＦＰを含む、パキスタンの公共工事プロジェクト計画、認可、実施の手順は次のとおりである。

1)　プロジェクトの存在確認：

地元住民代表と州の担当局との協議及び両者による現況調査⇨必要性の確認。

2)　プロジェクト概要書の作成：

通常、州の担当部内自体で作成するか、民間のコンサルタントに外注する。これをＰＣ－Ⅱと呼び、プロジェクトの必要性、概要とともに、概略予算と、フリーハンド程度もしくはそれ以上詳細な設計図を添付する。

ＰＣ－Ⅱの認可は、コンセプトクリアランス（Concept Clearance)といい、プロジェクト・コストがRs.6,000万までの場合は、担当局の次官を経由して、州の計画局（Planning and Development Dept.)が事務局である。Project Development Working Party(ＰＤＷＰ)に提出され、ここが認可権を持つ。

3)　認可されたプロジェクトは、新聞広告によりランク別登録業者３社以上の入札により、業者を次のように決定し、プロジェクトを実施する。

（Ｃ＆Ｗ Dept.の場合）　…………　その他の局もこれに準ずる。

— プロジェクトコストが	Rs. 50万まで	発注権	: Executive Engineer
— 〃	Rs.250万まで	〃	: Superintending Engineer
— 〃	Rs.500万まで	〃	: Chief Engineer
— 〃	Rs.500万以上	〃	: ３名のChief EngineerによるTender Approving Committee(ＴＡＣ）の協議で決定

4)　プロジェクト計画書の作成：

プロジェクトコストがRs.6,000万以上の場合、州の担当局は、プロジェクト計画書（ＰＣ－１）を作成し、担当局⇨州の計画局⇨連邦政府の担当省（Ｃ＆Ｗ Dept.の場合はMinistry of Communications）⇨連邦政府の計画省（Ministry of Planning and Development）の審査のあと、コンセプト・クリアランス認可を得る。この認可は計画省の大臣又は主席次官が委員長、局長クラスが委員で構成されるConcept Clearance Committee による。

5)　プロジェクト実施計画書：

プロジェクトのコンセプト・クリアランス認可後、州の担当局は、設計（通常は外注）を行い、詳細なプロジェクトの実施計画書を作成し、担当局⇨州の計画局⇨担当省⇨計画

省の審査のあと；

a） プロジェクトコストがRs.1億以下の場合

議長が計画大臣、委員が各省の次官と計画省の担当局長で構成されるCentral Development Working Party（ＣＤＷＰ）において、申請当事者の出席のもとプロジェクト認可の可否を決定する。

b） プロジェクト・コストがRs.1億以上の場合

a)のＣＤＷＰでの審査のあと、The Executive Committee of National Economic Council(ＥＣＮＥＣ－国家経済政策策定委員会）での審査により認可の可否が決定される。

認可されたプロジェクトは、申請とは逆のルートで州の担当局にもどり、新聞広告後、３名のChief Engineerで構成されるＴＡＣの協議会で業者が選定され、プロジェクトが実施される。

今回要請を受けた橋梁建設計画は、パキスタン国内では、すでにConcept Clearance 認可を得たもので、今後ＮＷＦＰのＣ＆W Dept.としては基本設計調査のデータをもとに実施計画の認可を取得する必要がある。

付属資料－6　収集資料リスト

番号	資料の名称	部数	収集先名称又は発行機関	備考
1	Organization Chart : Communications of Works Dept., NWFP.	1 部	C&W Dept. NWFP Joint	
2	Answers to Questionnaire (Engineering Data) on 20 Proposed Bridges.	各1部	Executive Engineers, C&W Dept., NWFP, Joint	
3	N.W.F.P. Development Statistics 1989.	1 冊	Bureau of Statistics P&D Dept., NWFP Joint	
4	Road Map 7　6 Districts, NWFP.			
	1) Abbottabad: Index Map of Highway Division Abbottabad. (s) 1/2" = 1 mile	1	C&W Dept. NWFP	
	2) Mansehra : Road Map of Mansehra District (s) 1" = 4 miles	1	〃	
	3) Kohistan : Road Map of Kohistan District (s) 1" = 4 miles	1	〃	
	: Map of District Kohistan (s) ?	1	〃	
	4) Dir : Index map of Dir District (s) 1" = 4 miles	1	〃	
	5) Swat : Road Map of Swat District (s) 1" = ?	1	〃	
	6) Malakand : Road Map of C&W Division Malakand (s) 1" = 1 mile	1	〃	
	7) Index Plan of Malakand Division (s)	1	〃	
5	7th Five-Year Plan 1988-93 and Perspective Plan 1988-2003 抜粋	1		
6	Letters of Request for Construction of Bridges			
	1) for Bridge at Harus Nullah at Dewal Feb 22.'92	1	Javed Iqbal Abbasi	
	2) for Bridge on Pind Gali Road over River Siran, Feb 26,'92.	1	Shahibzada Mhmd. Sabir Shafi	
7	Inventory of NWFP Highways (upto 30 June 1988)	1	C&W Dept., NWFP Joint	
8	List of Bridges included in the ADP-SDP/ 1991-92	1	〃	
9	ODA Grant Progress Report, 12/1991	1	〃	
10	Revenue, Expenditure of NWFP for 1988-89 to 1990-91	1	〃	
11	Replies to the Questionnaire	1	〃	
12	Reply to Questionnaire, No. ; Procedures and Formalities of Project Planning to Implementation	1	C&W Dept., Joint of NWFP.	

番号	資　料　の　名　称	部数	収集先名称又は 発行機関	備　考
13	Total No. of Dev. Schemes for 1991-92. Malakand Division	1	C&W Dept., Joint of NWFP.	
14	Mid Year Review of ADP 1991-92, Communication Sector	1	〃	
15	Monthly Progress Report for the Month of 11/91 of FATA A.D.P. 1991-92	1	〃	
16	Monthly Progress Report of Special Development Programme for the month of 11/1991.	1	〃	

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