APPENDICES

APPENDIX A

A.1 Occupancy Category of Buildings and Other Structures Flood, Wind, Snow, Earthquake and Ice Loads

Nature of Occupancy	Occupancy Category
Buildings and other structures that represent a low hazard to human life in the event of failure, including, but not limited to: • Agricultural facilities • Certain temporary facilities • Minor storage facilities	I
All buildings and other structures except those listed in Occupancy Categories I, III, and IV	II
Buildings and other structures that represent a substantial hazard to human life in the event of failure, including, but not limited to: • Buildings and other structures where more than 300 people congregate in one area • Buildings and other structures with daycare facilities with a capacity greater than 150 • Buildings and other structures with elementary school or secondary school facilities with a capacity greater than 250 • Buildings and other structures with a capacity greater than 500 for colleges or adult education facilities • Health care facilities with a capacity of 50 or more resident patients, but not having surgery or emergency treatment facilities • Jails and detention facilities Buildings and other structures, not included in Occupancy Category IV, with potential to cause a substantial economic impact and/or mass disruption of day-to-day civilian life in the event of failure, including, but not limited to: • Power generating stations[a] • Water treatment facilities • Sewage treatment facilities • Telecommunication centers Buildings and other structures not included in Occupancy Category IV (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives) containing sufficient quantities of toxic or explosive substances to be dangerous to the public if released. Buildings and other structures containing toxic or explosive substances shall be eligible for classification as Occupancy Category II structures if it can be demonstrated to the satisfaction of the authority having jurisdiction by a hazard assessment as described in Section 1.5.2 that a release of the toxic or explosive substances does not pose a threat to the public.	III
Buildings and other structures designated as essential facilities, including, but not limited to: • Hospitals and other health care facilities having surgery or emergency treatment facilities • Fire, rescue, ambulance, and police stations and emergency vehicle garages • Designated earthquake, hurricane, or other emergency shelters • Designated emergency preparedness, communication, and operation centers and other facilities required for emergency response • Power generating stations and other public utility facilities required in an emergency • Ancillary structures (including, but not limited to, communication towers, fuel storage tanks, cooling towers, electrical substation structures, fire water storage tanks or other structures housing or supporting water, or other fire-suppression material or equipment) required for operation of Occupancy Category IV structures during an emergency • Aviation control towers, air traffic control centers, and emergency aircraft hangars • Water storage facilities and pump structures required to maintain water pressure for fire suppression • Buildings and other structures having critical national defense functions Buildings and other structures (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, or hazardous waste) containing highly toxic substances where the quantity of the material exceeds a threshold quantity established by the authority having jurisdiction. Buildings and other structures containing highly toxic substances shall be eligible for classification as Occupancy Category II structures if it can be demonstrated to the satisfaction of the authority having jurisdiction by a hazard assessment as described in Section 1.5.2 that a release of the highly toxic substances does not pose a threat to the public. This reduced classification shall not be permitted if the buildings or other structures also function as essential facilities.	IV

A.2 Directionality Factor, K_d

Structure Type	Directionality Factor K_d*
Buildings Main Wind Force Resisting System Components and Cladding	0.85 0.85
Arched Roofs	0.85
Chimneys, Tanks, and Similar Structures Square Hexagonal Round	 0.90 0.95 0.95
Solid Signs	0.85
Open Signs and Lattice Framework	0.85
Trussed Towers Triangular, square, rectangular All other cross sections	 0.85 0.95

A.3 Important Factor, I

Category	Non-Hurricane Prone Regions and Hurricane Prone Regions with V = 85-100 mph and Alaska	Hurricane Prone Regions with V > 100 mph
I	0.87	0.77
II	1.00	1.00
III	1.15	1.15
IV	1.15	1.15

A.4 Internal Pressure Coefficients, GC_{pi}

Enclosure Classification	GC_{pi}
Open Buildings	0.00
Partially Enclosed Buildings	+0.55 -0.55
Enclosed Buildings	+0.18 -0.18

A.5 C_p for MWFRS: Walls

Wall Pressure Coefficients, C_p			
Surface	L/B	C_p	Use With
Windward Wall	All values	0.8	q_z
Leeward Wall	0-1	-0.5	q_h
	2	-0.3	
	≥4	-0.2	
Side Wall	All values	-0.7	q_h

A.6 C_p for MWFRS: Roofs

Roof Pressure Coefficients, C_p, for use with q_h

Wind Direction	Windward									Leeward		
	Angle, θ (degrees)									Angle, θ (degrees)		
	h/L	10	15	20	25	30	35	45	≥60#	10	15	≥20
Normal to ridge for θ ≥ 10°	≤0.25	-0.7 -0.18	-0.5 0.0*	-0.3 0.2	-0.2 0.3	-0.2 0.3	0.0* 0.4	0.4	0.01 θ	-0.3	-0.5	-0.6
	0.5	-0.9 -0.18	-0.7 -0.18	-0.4 0.0*	-0.3 0.2	-0.2 0.2	-0.2 0.3	0.0* 0.4	0.01 θ	-0.5	-0.5	-0.6
	≥1.0	-1.3** -0.18	-1.0 -0.18	-0.7 -0.18	-0.5 0.0*	-0.3 0.2	-0.2 0.2	0.0* 0.3	0.01 θ	-0.7	-0.6	-0.6

Normal to ridge for θ < 10 and Parallel to ridge for all θ		Horiz distance from windward edge	C_p
	≤ 0.5	0 to h/2	-0.9, -0.18
		h/2 to h	-0.9, -0.18
		h to 2 h	-0.5, -0.18
		> 2h	-0.3, -0.18
	≥ 1.0	0 to h/2	-1.3**, -0.18
		> h/2	-0.7, -0.18

*Value is provided for interpolation purposes.

**Value can be reduced linearly with area over which it is applicable as follows

Area (sq ft)	Reduction Factor
≤ 100 (9.3 sq m)	1.0
200 (23.2 sq m)	0.9
≥ 1000 (92.9 sq m)	0.8

A.7 Annual Highest Wind Speed in Khartoum, WL

Year	Highest Wind Speed (m/s)
1987	43
1988	52
1989	44
1990	29
1991	66
1992	61
1993	36
1994	35
1995	26
1996	21
1997	18
1998	49
1999	58
2000	31
2001	54
2002	69
2003	46
2004	57
2005	40
2006	39

A.8Minimum Uniformly Distributed Live Loads, LL, and Concentrated Live Loads

Occupancy or Use	Uniform psf (kN/m^2)	Conc. lb (kN)
Apartments (see *Residential*)		
Access floor systems		
Office use	50 (2.4)	2,000 (8.9)
Computer use	100 (4.79)	2,000 (8.9)
Armories and drill rooms	150 (7.18)	
Assembly areas and theaters		
Fixed seats (fastened to floor)	60 (2.87)	
Lobbies	100 (4.79)	
Movable seats	100 (4.79)	
Platforms (assembly)	100 (4.79)	
Stage floors	150 (7.18)	
Balconies (exterior)	100 (4.79)	
On one- and two-family residences only, and not exceeding 100 ft^2 (9.3 m^2)	60 (2.87)	
Bowling alleys, poolrooms, and similar recreational areas	75 (3.59)	
Catwalks for maintenance access	40 (1.92)	300 (1.33)
Corridors		
First floor	100 (4.79)	
Other floors, same as occupancy served except as indicated		
Dance halls and ballrooms	100 (4.79)	
Decks (patio and roof)		
Same as area served, or for the type of occupancy accommodated		
Dining rooms and restaurants	100 (4.79)	
Dwellings (see *Residential*)		
Elevator machine room grating (on area of 4 in.^{2} [2,580 mm^2])		300 (1.33)
Finish light floor plate construction (on area of 1 in.^{2} [645 mm^2])		200 (0.89)
Fire escapes	100 (4.79)	
On single-family dwellings only	40 (1.92)	
Fixed ladders	See Section 4.4	
Garages (passenger vehicles only)	40 (1.92)[a,b]	
Trucks and buses		
Grandstands (see *Stadiums and arenas, Bleachers*)		
Gymnasiums—main floors and balconies	100 (4.79)	
Handrails, guardrails, and grab bars	See Section 4.4	
Hospitals		
Operating rooms, laboratories	60 (2.87)	1,000 (4.45)
Patient rooms	40 (1.92)	1,000 (4.45)
Corridors above first floor	80 (3.83)	1,000 (4.45)
Hotels (see *Residential*)		
Libraries		
Reading rooms	60 (2.87)	1,000 (4.45)
Stack rooms	150 (7.18)[c]	1,000 (4.45)
Corridors above first floor	80 (3.83)	1,000 (4.45)
Manufacturing		
Light	125 (6.00)	2,000 (8.90)
Heavy	250 (11.97)	3,000 (13.40)
Marquees	75 (3.59)	
Office Buildings		
File and computer rooms shall be designed for heavier loads based on anticipated occupancy		
Lobbies and first-floor corridors	100 (4.79)	2,000 (8.90)
Offices	50 (2.40)	2,000 (8.90)
Corridors above first floor	80 (3.83)	2,000 (8.90)
Penal Institutions		
Cell blocks	40 (1.92)	
Corridors	100 (4.79)	
Residential		
Dwellings (one- and two-family)		
Uninhabitable attics without storage	10 (0.48)	
Uninhabitable attics with storage	20 (0.96)	
Habitable attics and sleeping areas	30 (1.44)	
All other areas except stairs and balconies	40 (1.92)	
Hotels and multifamily houses		
Private rooms and corridors serving them	40 (1.92)	
Public rooms and corridors serving them	100 (4.79)	
Reviewing stands, grandstands, and bleachers	100 (4.79)[d]	

Occupancy or Use	Uniform psf (kN/m²)	Conc. lb (kN)
Roofs		
Ordinary flat, pitched, and curved roofs	20 (0.96)[h]	
Roofs used for promenade purposes	60 (2.87)	
Roofs used for roof gardens or assembly purposes	100 (4.79)	
Roofs used for other special purposes	[i]	[i]
Awnings and canopies		
Fabric construction supported by a lightweight rigid skeleton structure	5 (0.24) nonreduceable	
All other construction	20 (0.96)	
Primary roof members, exposed to a work floor		
Single panel point of lower chord of roof trusses or any point along primary structural members supporting roofs over manufacturing, storage warehouses, and repair garages		2,000 (8.9)
All other occupancies		300 (1.33)
All roof surfaces subject to maintenance workers		300 (1.33)
Schools		
Classrooms	40 (1.92)	1,000 (4.45)
Corridors above first floor	80 (3.83)	1,000 (4.45)
First-floor corridors	100 (4.79)	1,000 (4.45)
Scuttles, skylight ribs, and accessible ceilings		200 (0.89)
Sidewalks, vehicular driveways, and yards subject to trucking	250 (11.97)[e]	8,000 (35.60)[f]
Stadiums and arenas		
Bleachers	100 (4.79)[d]	
Fixed seats (fastened to floor)	60 (2.87)[d]	
Stairs and exit ways	100 (4.79)	[g]
One- and two-family residences only	40 (1.92)	
Storage areas above ceilings	20 (0.96)	
Storage warehouses (shall be designed for heavier loads if required for anticipated storage)		
Light	125 (6.00)	
Heavy	250 (11.97)	
Stores		
Retail		
First floor	100 (4.79)	1,000 (4.45)
Upper floors	75 (3.59)	1,000 (4.45)
Wholesale, all floors	125 (6.00)	1,000 (4.45)
Vehicle barriers	See Section 4.4	
Walkways and elevated platforms (other than exit ways)	60 (2.87)	
Yards and terraces, pedestrian	100 (4.79)	

[a] Floors in garages or portions of a building used for the storage of motor vehicles shall be designed for the uniformly distributed live loads of Table 4-1 or the following concentrated load: (1) for garages restricted to passenger vehicles accommodating not more than nine passengers, 3,000 lb (13.35 kN) acting on an area of 4.5 in. by 4.5 in. (114 mm by 114 mm) footprint of a jack; and (2) for mechanical parking structures without slab or deck that are used for storing passenger car only, 2,250 lb (10 kN) per wheel.

[b] Garages accommodating trucks and buses shall be designed in accordance with an approved method, which contains provisions for truck and bus loadings.

[c] The loading applies to stack room floors that support nonmobile, double-faced library book stacks subject to the following limitations: (1) The nominal book stack unit height shall not exceed 90 in. (2290 mm); (2) the nominal shelf depth shall not exceed 12 in. (305 mm) for each face; and (3) parallel rows of double-faced book stacks shall be separated by aisles not less than 36 in. (914 mm) wide.

[d] In addition to the vertical live loads, the design shall include horizontal swaying forces applied to each row of the seats as follows: 24 lb per linear ft of seat applied in a direction parallel to each row of seats and 10 lb per linear ft of seat applied in a direction perpendicular to each row of seats. The parallel and perpendicular horizontal swaying forces need not be applied simultaneously.

[e] Other uniform loads in accordance with an approved method, which contains provisions for truck loadings, shall also be considered where appropriate.

[f] The concentrated wheel load shall be applied on an area of 4.5 in. by 4.5 in. (114 mm by 114 mm) footprint of a jack.

[g] Minimum concentrated load on stair treads (on area of 4 in.^{2} [2,580 mm^2]) is 300 lb (1.33 kN).

[h] Where uniform roof live loads are reduced to less than 20 lb/ft^2 (0.96 kN/m^2) in accordance with Section 4.9.1 and are applied to the design of structural members arranged so as to create continuity, the reduced roof live load shall be applied to adjacent spans or to alternate spans, whichever produces the greatest unfavorable effect.

[i] Roofs used for other special purposes shall be designed for appropriate loads as approved by the authority having jurisdiction.

APPENDIX B

B.1 Values of Modulus of Elasticity, E for Normal-Weight Concrete

f_c(MPa)	E_c(MPa)
17	17450
21	21500
24	23000
28	24900
35	27800
42	30450

B.2 Designation, Diameters, Areas, Perimeters, and Masses of Metric Bars

Bar no	Nominal dimension		
	Diameter (mm)	Area (mm^2)	Mass (kg/m)
10	9.5	71	0.560
13	12.7	129	0.994
16	15.9	199	1.552
19	19.1	284	2.235
22	22.2	387	3.042
25	25.4	510	3.973
29	28.7	645	5.060
32	32.3	819	6.404
36	35.8	1006	7.907
43	43	1452	11.38
57	57.3	2581	20.24

B.3 Area of Groups of Standard Metric Bars (mm^2)

Bar Design	Number of Bars								
	2	3	4	5	6	7	8	9	10
#10	142	213	284	355	426	497	568	639	710
#13	258	387	516	645	774	903	1032	1161	1290
#16	398	597	796	995	1194	1393	1592	1791	1990
#19	568	852	1136	1420	1704	1988	2272	2556	2840
#22	774	1161	1548	1935	2322	2709	3096	3483	3870
#25	1020	1530	2040	2550	3060	3570	4080	4590	5100
#29	1290	1935	2580	3225	3870	4515	5160	5805	6450
#32	1638	2457	3276	4095	4914	5733	6552	7371	8190
#36	2012	3018	4024	5030	6036	7042	8048	9054	10060
#43	2904	4356	5808	7260	8712	10162	11616	13068	14520
#57	5162	7743	10324	12905	15486	18067	20648	23229	25810

B.3 Continued

Bar Design	Number of Bars									
	11	12	13	14	15	16	17	18	19	20
#10	781	852	923	994	1065	1136	1207	1278	1349	1420

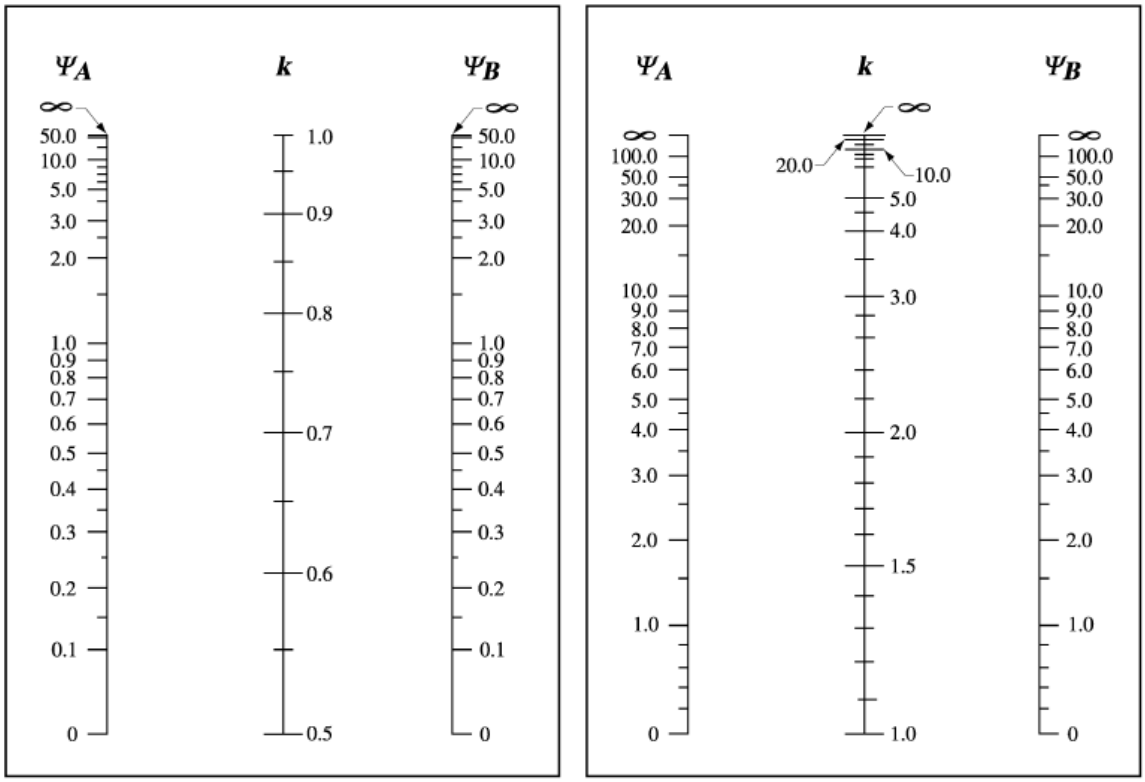
#13	1419	1548	1677	1806	1935	2064	2193	2322	2451	2580
#16	2189	2388	2587	2786	2985	3184	3383	3582	3781	3980
#19	3124	3408	3692	3976	4260	4544	4828	5112	5396	5680
#22	4257	4644	5031	5418	5805	6192	6579	6966	7353	7740
#25	5610	6120	6630	7140	7650	8160	8670	9180	9690	10200
#29	7095	7740	8385	9030	9675	10320	10965	11610	12255	12900
#32	9009	9828	10647	11466	12285	13104	13913	14742	15561	16380
#36	11066	12072	13078	14084	15090	16096	17102	18108	19114	20120
#43	15972	17424	18876	20328	21780	23232	24648	26136	27588	29040
#57	28391	30972	33553	36134	38715	41296	43877	46458	49039	51620

B.4 Values of ρ Balanced, ρ to Achieve Various ε_t Values, and ρ Minimum for Flexure. All Values are for Tensile Reinforced Rectangular Sections

$F_{y\ (MPa)}$	$F'_{c(MPa)}$	21 $\beta_1 = 0.85$	28 $\beta_1 = 0.85$	35 $\beta_1 =$ 0.814	42 $\beta_1 =$ 0.764
300	ρ balanced	0.00337	0.0450	0.0538	.0606
	ρ when $\varepsilon_t = .004$	0.0217	0.0289	0.0346	0.0390
	ρ when $\varepsilon_t = .005$	0.0190	0.0253	0.0303	0.0341
	ρ when $\varepsilon_t = .075$	0.0144	0.0193	0.0231	0.0260
	ρ min for flexure	0.0047	0.0047	0.0049	0.0054

350	ρ balanced	0.0274	0.0365	0.0437	0.0492
	ρ when ε_t =.004	0.0186	0.0248	0.0297	0.0334
	ρ when ε_t =.005	0.0163	0.0217	0.0259	0.0292
	ρ when ε_t =.075	0.0124	0.0165	0.0198	0.0223
	ρ min for flexure	0.0040	0.0040	0.0042	0.0046
420	ρ balanced	0.0212	0.0283	0.0339	0.0382
	ρ when ε_t =.004	0.0155	0.0206	0.0247	0.0278
	ρ when ε_t =.005	0.0135	0.0181	0.0216	0.0244
	ρ when ε_t =.075	0.0103	0.0138	0.0165	0.0186
	ρ min for flexure	0.0033	0.0033	0.0038	0.0039

B.5Effective Length Factor (k)



(a)
Nonsway Frames

(b)
Sway Frames

Ψ = ratio of Σ(EI/ℓ_c) of compression members to Σ(EI/ℓ) of flexural members in a plane at one end of a compression member

ℓ = span length of flexural member measured center to center of joints

B.6 Strength Reduction Factor (Ø)

Strength Condition	Strength Reduction Factor
Tension-controlled sections	0.90
Compression-controlled sections[a]	
Members with spiral reinforcement	0.70
Other reinforced members	0.65
Shear and torsion	0.75
Bearing on concrete	0.65
Post-tensioned anchorage zones	0.85
Strut-and-tie models[b]	0.75