

Administrative Resolution No. (37) of 2021
Amending the
Bylaw Concerning Building Requirements and Specifications¹

The Director General of the Dubai Municipality,

After perusal of:

The Order of 1961 Establishing the Dubai Municipality (the “**DM**”);

Local Order No. (3) of 1999 Regulating Construction Works in the Emirate of Dubai and its amendments; and

Administrative Resolution No. (125) of 2001 Approving the Bylaw Concerning Building Requirements and Specifications,

Does hereby issue this Resolution.

Superseded Articles
Article (1)

Articles (53), (54), (55), and (57) of the Bylaw Concerning Building Requirements and Specifications approved under the above-mentioned Administrative Resolution No. (125) of 2001 are hereby superseded by the following:

Structural Design Requirements
Article (53)

In preparing the structural design of Buildings and structures, the following requirements must be fulfilled:

- a. The structural design of Buildings and structures must be prepared by a qualified structural Engineer licensed, under the applicable legislation, to practise the engineering consultancy profession in the Emirate, and accredited by the Competent Department.

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¹Every effort has been made to produce an accurate and complete English version of this legislation. However, for the purpose of its interpretation and application, reference must be made to the original Arabic text. In case of conflict, the Arabic text will prevail.

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- b. The Contractor or Engineer in charge must, in performing his work, use only the approved and licensed smart applications and technical and computer programmes, in accordance with the regulations in force in the Emirate;
- c. The Buildings and structures, and all components thereof and materials used therein, must meet the standards and requirements that ensure their durability and safety against the following factors:
 - 1. the most critical forces and loads, or combinations thereof, in respect of impact on structures or Buildings, including the combinations of forces and loads that may lead to progressive collapse; and
 - 2. any other factors that may affect the Building, including steel corrosion and rust or residual stresses that the Building may be subjected to.

Approved Building Codes

Article (54)

Buildings and structures will be designed in accordance with the following codes:

a. Concrete Structures Codes

Structures and Buildings must be designed in accordance with the latest editions of the American, European, or British standard codes and specifications as follows:

Load Codes

1. Dead and Live Loads Affecting Buildings

Live and dead loads will be calculated in accordance with the American code, European code, or British code, taking into account the following:

- 1.1 Live load on Mezzanine Floor must not be less than five kilonewtons per square metre (5 kN/m²).
- 1.2 Live load must not be less than three kilonewtons per square metre (3 kN /m²) in car parking Buildings and car parking Floors in other Buildings, taking into consideration the loads of car movement lanes, and using the modal load pattern in design.
- 1.3 Live load in flat slab designs and post-tensioned slab designs must not be less than three kilonewtons per square metre (3 kN/m²) in all Buildings that may be exposed to live load less than such a figure. The designer can use the values in the Code (2

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kN/m²), provided that he uses the modal loads pattern in the design and takes into account all the installations in the ceiling.

- 1.4 The minimum values for dead loads of the slabs will be determined in accordance with the following table:

Type of Partition	Dead load Min. kN/m ²
Light Weight Partitions	4.5
Normal Weight Partitions	5.5
Dry Wall Partitions	4
Façade Cladding	1.5 kN/m

The loads applicable to all types of internal partitions installed on slabs and façade claddings may be less than the values set out in the above-mentioned Table, provided that the required calculations of actual loads are submitted as per the adopted system and stated in the drawings submitted for obtaining the permit. Further modifications to the Buildings may be made, subject to obtaining a new approval from the DM upon satisfying the relevant requirements prescribed by it.

2. Wind Loads

- 2.1 The American Society of Civil Engineers Code (ASCE7-5/ ASCE7-10 / ASCE7-16) or the European Code and any updates and amendments thereto, or any other code approved by the competent authority.
- 2.2 For calculating design wind speed (strength design), service wind speed (service design), and load factors, reference must be made to the table below:

Design Wind Speed (Strength Design)

Mean Recurrence Interval (Years)	Wind Speed (m/s, 3-sec gust, 10 m, open terrain)	
	Strength	Load Factor
50 ^{II}	38	1.6*
100 ^{III,IV}	40	1.6*
300 ^I	44	1**
700 ^{II}	47	1**
1000	49	1**
1700 ^{III}	51	1**
3000 ^{IV}	53	1**

*to be used with a Wind Load Factor of 1.6 for ASCE 7-05 strength design approach (specified wind X load factor)

** to be used with a Wind Load Factor of 1.0 for ASCE 7-10/ASCE 7-16 strength design approach (ultimate limit state ULS wind load)

(I, II, III, IV are ASCE 7 Building Risk Categories)

Service Wind Speed (Service Design)		
Mean Recurrence Interval (Years)	Wind Speed (m/s, 3-sec gust, 10 m, open terrain)	
	Service	Load Factor
1	22	1**
10	30	1**
25	34	1**
50	36	1**

** to be used with a Wind Load Factor of 1.0 for ASCE7-10/ASCE 7-16 service design approach (serviceability limit state SLS wind load)

Wind speed for temporary Buildings will be calculated based on thirty-two metres per second (32 m / sec on 3 sec) gust for fifty (50) years return period for building category II

- 2.3 Reference must be made to the following Table for checking wind speed as per building codes other than the American Society of Civil Engineers Code (ASCE 7):

Mean Recurrence Interval (Years)	Effective Wind Speed (m/s, 10 m, open terrain)		
	3 Second Gust	10-minute Mean	Mean Hourly
10	28	19.5	18.4
25	30	20.9	19.7
50	36	25	23.6
100	39	27.1	25.6
700	45	31.3	29.5
1700	48	33.4	31.5
3000	50	34.8	32.8

- 2.4 In any event, the design wind load for Buildings and steel structures must not be less than one kilonewton per square metre (1kN/m²).
- 2.5 Wind loads will be calculated based on the wind tunnel model for Buildings with a height of one hundred and twenty (120) metres above ground level for regular shaped Buildings. For irregular shaped Buildings with curves and sharp edges on the façades, the wind tunnel model is required regardless of the height of the Building.
- 2.6 The damping coefficient for concrete Buildings is determined based on the studies submitted by the consulting Engineer and the wind tunnel test consultant, within the values shown in the following Table:

Loads	Damping Coefficient	
	Concrete Buildings	Steel Buildings
Service Loads	1% – 2%	0.75% - 1%
Design Loads	1.5% - 2.5%	1% - 1.5%

3. Thermal Loads:

Thermal loads will be taken into account based on the following Table:

TYPE OF ELEMENT	ΔTC
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Exposed elements	20C
Non-exposed elements	15C
Steel Structures	25C

Early and seasonal thermal loads and their effects may be calculated based on the Ciria Report No. 660 standard.

In calculating thermal loads, the value of the axial stiffness modifier will be as follows:

- (1.0) for reinforced concrete slabs of typical Floors.

4. Earthquake Loads

- 4.1 The American Society of Civil Engineers Code (ASCE 7), and any updates or amendments thereto.
- 4.2 The values of ground motion parameters used for critical damping ratio of five percent (5%) and shear wave velocity (760 M/S) will be determined based on the following Table:

PGA (g)	S_S (g)	S_1 (g)	T_L (s)
0.2	0.51	0.18	24

- i. PGA , S_S , and S_1 coefficients will be modified in accordance with the nature of the soil using Site Amplification Factors F_{PGA} , F_a , and F_v by reference to Tables 11.8-1, 11.4-1, and 11.4-2 respectively in the American Society of Civil Engineers Code (ASCE 7).
 - ii. If the Shear Wave Velocity of rocks for site Class B is estimated instead of measured, then the formula $F_{PGA} = F_a = F_v = 1$ cited in ASCE 7 must be used for such a site. The modified values of the PGA , S_S , and S_1 coefficients are denoted as PGA_M , S_{MS} , and S_{M1} respectively in ASCE 7.
- 4.3 The PGA_M coefficient is used for conducting calculations in the soil liquefaction analysis. The seismic force considered for determining the PGA_M coefficient in the Emirate is M 6.2.
 - 4.4 Seismic Importance Factor I_e can be determined for each Building based on Table 1.5-2 of the American Society of Civil Engineers Code (ASCE 7).
 - 4.5 Ground Motion Parameters for Buildings with Critical Damping ratio other than five percent (5%) will be calculated by dividing the coefficients S_{MS} and S_{M1} by the

damping-adjustment factors β_s and β_1 consecutively as shown in the following Table:

- 4.6 Soil reaction coefficient will be calculated in compliance with the recommendations mentioned in the soil investigation report of the relevant project.

Damping, ζ (%)	β_s	β_1
0.5	0.47	0.54
2	0.72	0.78
5	1	1
10	1.4	1.3
20	1.9	1.7
30	2.3	2.1

- 4.7 The seismic mass is comprised of:

- 25% of the storage live loads
- 100% of the mechanical live loads
- 100% of the dead loads

b. Steel Structures Codes

Steel structures and Buildings must be designed in accordance with the latest editions of the American, European, or British standard codes and specifications as follows:

1. The American Institute of Steel Construction Specifications for Structural Steel Buildings
 - Specification for Structural Steel Buildings (AISC 360).
 - Seismic Provisions for Structural Steel Buildings (AISC 341).
2. Standard Specifications for Plain and Steel-Laminated Elastomeric Bearings for Bridges (ASTM D4014-03).
3. Standard Specifications for High Load Rotational Spherical Bearings for Bridges and Structures (ASTM D5977-03).

4. Load and Resistance Factor Design (LRFD) for Highway Bridge Superstructures by the American Association of State Highway and Transportation Officials (AASHTO).
5. Minimum Design Loads and Associated Criteria for Buildings and Other Structures by the American Society of Civil Engineers (ASCE 7-05 / ASCE 7-10 / ASCE 7-16).
6. The Structural Welding Code: Steel by the American Welding Society (AWS D1.1 / D1.1M).
7. Structural Welding Code: Reinforcing steel by the American Welding Society (AWS D1.4/D1.4M).
8. Structural Welding Code: Seismic Supplement of the American Welding Society (AWS D1.8/D1.8M).
9. The latest edition of the Metal Building Systems Manual of the Metal Building Manufacturers Association (MBMA 2006 & MBMA 2010).
10. Eurocode 3: Design of steel structures (BS EN 1993-1-1 TO 12).
11. The British Standard Code of Practice (BS-6399 Part 13): Loading for buildings.
12. The British Standard Code of Practice (BS-5400): Design and construction of steel, concrete and composite bridges.
13. The British Standard Code of Practice (BS 5950): Structural use of steelwork in building.

c. Codes for Concrete Masonry Blocks

The British Standard Code of Practice for use of concrete masonry blocks (BS 5628 part 1:1978/1985 as read with BS 5628 part 3) as well as the local orders and resolutions on concrete masonry blocks, issued by the DM, must be complied with.

d. Codes for Aluminium Structures

The British Standard Code of Practice for Structural Use of Aluminium 118 -1969 (CP 118:1969)

e. Codes for Timber Structures

The British Standard Code of Practice for structural use of timber (BS 5628 part2: 1989 & BS 5628 part 3: 1985)

f. Other Design Codes

Subject to obtaining the relevant approval of the Competent Department, structural designs may be prepared by reference to building codes other than those mentioned above.

Design and Execution Criteria

Article (55)

a. Concrete Structures

To prevent the occurrence of progressive and disproportionate collapse in all structures, the latest editions of the references on the classifications and design of Buildings, and the design purposes and mechanism, must be used as follows:

1. Lateral Force Resisting Design

- A Building must be designed to withstand seismic forces, wind effect, the presumed central lateral force defined in Article (54) of this Bylaw. The details of the steel reinforcements must conform to the earthquake resistant design requirements.
2. The maximum allowable deflection value after installing joints of slabs and beams must not exceed $(L/480)$ up to (20) mm, to prevent cracks in joints and finishes.
3. Façade deflection: The overall drift and inter-storey drift will be calculated from $L/400$ to $L/600$. The design of the façade must be evaluated by a specialist consultant. The façade deflection includes dimensions of the spacers, allowable variance ratios in their manufacture/ installation, and thermal expansion. The lateral inter-storey drift may not exceed 10 mm. Where the lateral inter-storey drift exceeds this limit, special details must be provided for the installation of non-structural elements. Façade performance specifications, including drift limits, must be provided for use by the execution Contractor in determining the final dimensions of the spacers.
4. The minimum vertical reinforcement will be one percent (1%) in columns and four tenth percent (0.4 %) in walls, and the minimum horizontal reinforcement will be (0.25%). The diameter of stirrups in columns and walls with a vertical reinforcement ratio greater than one percent (1%) must not be less than ten millimetres (10 mm), with maximum allowed spacing between stirrups.
5. The maximum concrete compressive strength will be ninety Newton per square millimetre (90 N/ mm²) and the minimum concrete compressive strength will be thirty-five Newton per square millimetre (35 N/ mm²) for blocks.

6. The maximum reinforcement limit in reinforced columns and walls must not exceed four percent (4%), but can reach eight percent (8%) in the case of using couplers.
7. In designing pile caps, the latest Concrete Reinforcing Steel Institute (CRSI) standards must be referred to.
8. Tolerable crack widths in reinforced concrete structures will be designed as per the American Concrete Institute Code (ACI 224R Table 4.1) or Eurocode 2 (BS EN 1992-3 Section 7.3). When waterproofing is used for structural elements that cannot be accessed for maintenance, they will be considered as non-insulated elements.
9. Design Crack Widths
 - Below the foundations and retaining walls that are exposed to water pressure = 0.2 mm
 - Above the foundations and retaining walls that are not exposed to water pressure = 0.3 mm

The above values must not conflict with the requirements prescribed by the above-mentioned building codes, and a full waterproof tanking system must be provided for all elements that are exposed to water.

10. Concrete Modulus of Elasticity

- a. For normal strength concrete with a cylinder strength that is less than 55 N/mm²:
 - The modulus of elasticity of concrete will be calculated based on the ACI 318 code equation No. (19.2.2.1.a):

$$(0.043 \times W_c^{1.5} \times (f'_c)^{0.5})$$
- b. For high strength concrete with a cylinder strength beyond 55 N/mm²:
 - The modulus of elasticity of concrete will be calculated based on either of the following two options:
 1. Equation No. (1-6) of the ACI 363R Building Code; or
 2. by calculating the actual value of the modulus of elasticity based on the necessary laboratory tests of concrete mixtures, in accordance with the requirements of clause 19.2.2.2 in the ACI 318-19 Standard Code. The value of the modulus of elasticity must be indicated on the drawings submitted to the DM along with an undertaking to ensure that the actual values of the modulus of elasticity of concrete conform to the design before and during execution.

b. Steel Structures

1. Design Loads

1.1 Primary design loads include live and dead loads; and seismic and wind loads. As for other design loads, such as mechanical devices and equipment (static or dynamic), they are classified as secondary loads.

1.2 Loads are applied based on the code used. All the loads stated below are minimum design loads requirements:

- Roof dead load: 0.25 kN / m^2
- Pitched roof live load: 0.60 kN/m^2
- Flat roof live load: 0.75 kN / m^2
- Other roof loads to which a roof is exposed: 0.25 kN/m^2
- Wind speed: Based on wind speed specified in Article 54 on wind loads
- Minimum design wind load: 1 kN/m^2
- Seismic Importance Factor: 1
- Exposure category: (C) based on the latest edition of the (MBMA) the Metal Building Manufacturers Association Manual
- Winches loads: Based on factory specifications
- Thermal load: ($\pm 25 \text{ }^\circ\text{C}$)
- Dead load of the Mezzanine Floor: 3 kN / m^2
- Live load of the Mezzanine Floor: 5 kN / m^2

1.3 The primary design loads for walls and roofs will be as follows:

- Wind load must be calculated based on the wind speed prescribed by the local legislation in force in the Emirate
- The degree of exposure to external environment will be determined as per Categories C and D (open, closed).
- The Seismic Importance Factor will be determined based on the use of the Building.
- All primary and secondary loads must be specified and indicated in the drawings.
- The earthquake zone will be determined in accordance with the local legislation in force in the Emirate.
- Loads will be calculated in accordance with the latest edition of the Metal Building Manufacturers Association (MBMA) Manual.

1.4 Each structural element is designed according to the stress resulting from a combination of loads, taking into account the maximum ratio of actual stress to allowable stress in the element in accordance with the applicable code. The ultimate deflection of each structural element will be as follows:

- $(L/240)$ for deflection of the primary horizontal elements caused by live and dead loads
- $(L/360)$ for deflection of the primary horizontal elements caused only by live loads
- $(H/200)$ for deflection of vertical elements of brickwork with a height greater than 2.4 m
- $(H/100)$ for deflection of vertical elements (for buildings with metal cladding)

1.5 Minimum metal sheet thickness is six millimetres (6 mm) in case of built-up sections.

2. Quality Control

2.1 Welding

- Special welding procedures must be compliant with the requirements of AWS D1.1 / D1.1M:2015 / BS EN ISO 15614
- All welding work teams must be qualified as per the requirements stipulated in AWS D1.1 M:2015 / BS EN ISO 9606-1, BS EN ISO 14732, and must hold certificates accredited by independent inspection bodies.
- On-site welding work is prohibited, and if welding work is required to be done on-site, the detailed work process and the required certificates and tests must be provided, and the work may be carried out only by Certified Welders.

2.1 Inspection and Examination System

2.2.1 Inspection and examination during the assembly process for the welding work of elements fabricated in the factory and on-site will be conducted as follows:

- Testing and certification of welders must be carried out in accordance with the standards required by the DM. The types and locations of faulty work and the procedures required for addressing faults must be documented.
- Visual inspection of all welding works must be done.
- Welding tests must be conducted in accordance with the following standards:

1. Standard Test Method for Liquid Penetrant Inspection (ASTM E 165);

2. Magnetic Particle Testing of Welds BS 4397;
3. Radiographic Examination (BS-2600) and minimum quality level image test 2-2T
4. BS 3923 - Methods for Ultrasonic Examination of Welds

2.2.2 Inspection of Welds

- The Contractor must obtain the consultant's approval of the details of the control and quality system proposed for use during welding works, as well as his approval of conducting welding on site.
- The personnel to be engaged must be certified and adequately trained to document the welding procedures agreed upon by the qualified welders, to conduct visual inspection of the welds, and to record the findings of the dimensional inspection.

2.2.3 Extent of Inspection

Welds will be classified by Engineers into Category "A" and Category "B". However, the acceptance determinants must be the same for both categories, and the extent of inspection must be as follows:

- Category "A" Weld;
One hundred percent (100%) successful visual inspection of the weld must be accomplished prior to commencement of subsequent works, and the same percentage must be accomplished after the final weld, to ensure conformity to the BS 5135 specifications.
- Category "B" Weld:
A minimum of ten percent (10%) visual inspection of the weld must be accomplished upon successful completion of the initial testing; and a minimum of twenty percent (20%) visual inspection of each weld must be accomplished upon successful completion of the final weld testing, to ensure conformity to the BS 5135 specifications.

2.2.4 Weld Categories

Weld categories will be as follows:

- Category "A":
 1. butt joint welds for metal elements; and
 2. butt joint welds for metal elements subjected to large loads or bending moments, at the discretion of the supervising Engineer.
- Category "B":

All other welds not included in Category "A"

2.2.5 Non-destructive testing (NDT)

This must include, without limitation, the following:

- Liquid Penetrant Inspection (LPI)
- Magnetic Particle Inspection (MPI)
- Radiographic Testing (RT)
- Ultrasonic Testing (UT)

All the above-mentioned tests must be conducted in accordance with the British Standard Code of Practice (BS 5135).

2.2.6 Performing Non-destructive Testing

- Welding must be examined based on the following:

Welding type	Testing:
Full penetration of butt welds	100% Ultrasonic Testing and 100% Magnetic Particles Inspection (MPI) or Liquid Penetrant Inspection must be achieved
Partial penetration of butt welds	100% Ultrasonic Testing and 100% Magnetic Particles Testing must be achieved
Fillet Welds	A minimum of 30% Magnetic Particles Testing or Liquid Penetrant Inspection must be achieved

- In conducting a comprehensive performance evaluation of transverse fillet welds, the Ultrasonic Testing and/ or Radiographic Testing must be run.
- Magnetic Particles Inspection and/ or Dye Penetrant Inspection will be used when inspecting the outer surface of the weld or checking the success of the lap joint weld inspection

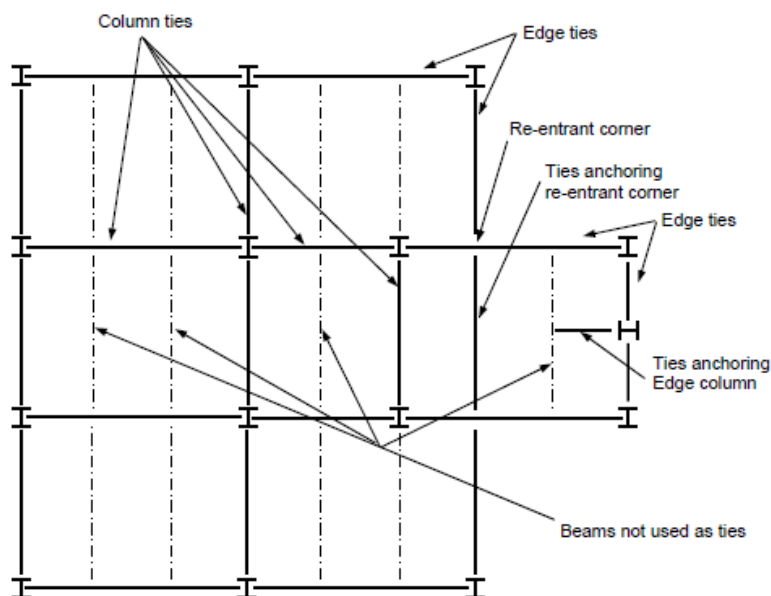
3. Inspection

Periodic maintenance reports must be submitted every five (5) years to ensure the structural efficiency and integrity of the structures.

4. Structural Integrity and Robustness

To ensure structural efficiency and robustness and reduce the risk of local damage caused by progressive collapse, Buildings must meet the following criteria:

- vertical and horizontal structural ties must be provided;
- the capacity to resist minimum lateral forces, as per the applicable code, must be ensured;
- the possibility of removing the vertical structural element and redistribution of forces to prevent damage or collapse of the main structure must be allowed, so that the resulting deflections of the remaining structural elements are within acceptable limits when removing any element; and
- the basic elements must be designed in accordance with the applicable code indicated in the chart below.

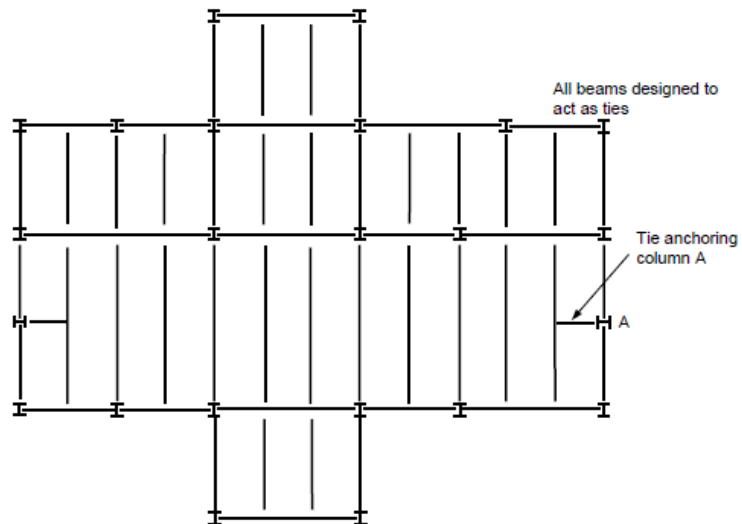


5. Avoiding Disproportionate Collapses

Steel-framed buildings designed in compliance with the applicable code instructions may be assumed not to be susceptible to disproportionate collapses, subject to satisfying the following requirements:

- The horizontal ties must be generally set up in a way that ensures the maximum possible robustness, durability, and sustainability. Horizontal ties must be provided in two perpendicular directions at each Floor and roof level.

- All columns must be carried through at each beam-to-column connection unless the steel frame is fully continuous in at least one direction. All columns splices must be capable of resisting a tensile force equal to the largest factored vertical reaction, from the dead and imposed loads, from the dead load, or from the wind and imposed loads, applied on the column at a single Floor level located between that column splice and the next column splice below.
- Ties or other lateral force resisting systems must be distributed to the Building in two orthogonal directions as per the applicable codes. No part of the Building may connect to the lateral force resisting system with only one point.
- Where precast concrete or any other solid construction systems are used, they must be tightly connected at their own level by bonding them together at the bearings level or tying them directly to the bearings, as recommended by the applicable code.



- If the above requirement is not fulfilled, each Floor must be checked to ensure that disproportionate collapses will not occur upon the hypothetical removal of any element of the lateral force resistance systems, one at a time, and that the area of the part at risk of collapse does not exceed fifteen (15%) of the area of that Floor or roof, or exceed 70 m², whichever is smaller, whether at the affected level or the immediately adjacent upper or lower levels.
- Where the hypothetical removal of a column, or any element of a lateral force resistance system, increases the risk of collapses in larger areas in excess of the above limit, then this column or element must be designed as a key element as recommended by the adopted code. The key elements and ties must be designed to withstand an accidental 34 kN/m² explosion or vehicle collision.

6. Loads During Construction

Loads arising from construction works must be taken into consideration.

7. Load Factors and Combinations

In carrying out construction works, the various types of loads and load combinations acting on a structure must be taken into consideration.

8. Wind-induced Oscillation

Wind-induced vibrations and oscillations within a structure must be mitigated to avoid causing disturbance for its users or damage to its contents. In case of special structures, including Buildings with large spans, roofs of large sports arenas, and chimneys, it is advisable to conduct the wind tunnel test to verify the operational limits of the structure.

9. Types of Corrosion Protection

Information on the proposed maintenance system, such as galvanisation, protective concrete coating, protective paint, and similar systems, must be taken into account when choosing the right corrosion protection system.

10. Operational Requirements

- upwards arching;
- expansion and shrinkage;
- deflections, vibrations, and displacements;
- sliding joints;
- corrosion; and
- durability.

11. Fire Resistance

- All Buildings must be designed to withstand fire for the period specified in the applicable code. However, the said period must not be less than two (2) hours.
- The fire resistance rating of a Building must be determined based on the type, uses, hazard assessment, and occupancy of the Building.
- The type of the fire protection required to be achieved based on the classification rating will be determined in accordance with the following criteria:
 1. the required fire-resistance period;
 2. the fire protection system in use;
 3. perimeter of the steel section exposed to fire;
 4. log and size of the steel section; and

5. Building use and occupancy.

- All proposed and approved fire-protection products and systems must be inspected by the Dubai Central Laboratory or the accredited laboratories in accordance with the adopted codes and standards.
- All details related to fire protection, such as the fire rating of columns, slabs, and roofs, as well as the proposed customised fire protection system and other necessary details, must be included in the relevant drawings.
- All details relating to fire protection must meet the requirements of the concerned authorities, such as Civil Defence, and be in line with the local legislation in force in the Emirate.

12. Architectural Exposed Steel Structures

These structures must meet the allowable limits for fabrication and erection as per the AISC code. Where the AISC code allowable limits are less than the values prescribed in this Bylaw, the most influential values must be observed.

c. Prestressed Concrete

The following rules and requirements must be satisfied:

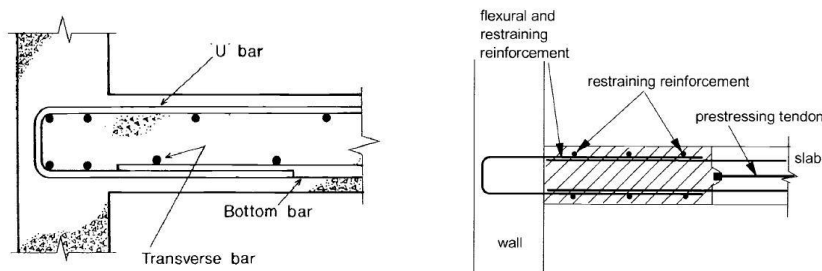
1. Only the Dubai Central Laboratory certified tensile strands with nominal tensile strength of one thousand eight hundred and sixty megapascal (1860 MPa) must be used.
2. The wall thickness of metal ducts must not be less than four tenth of a millimetre (0.4 mm). Galvanized flat or corrugated metal ducts can be used.
3. The minimum thickness for prestressed concrete slabs is two hundred millimetres (200 mm). An approval must be obtained prior to using thinner slabs.
4. Grouting: The grouting mixture consists of cement, water, and shrinkage compensating materials. The minimum strength of the grout mix after twenty-eight (28) days must be the same as the minimum strength of concrete, with a maximum accepted tolerance of twelve Newton per square millimetre (12 N/ mm²) from concrete characteristic strength, but must not be less than twenty-five Newton per square millimetre (25 N/ mm²) in any case.
5. An inspection at the start of the grouting procedure must be carried out by the consultant and noted in the drawings.
6. The resistance of concrete cubes used in prestressed slabs must not be less than (35 N/ mm²) at twenty-eight (28) days. In the transitional phase, it must be at least (25 N/ mm²).

7. The concrete cover must satisfy the highest value of durability requirements or fire resistance requirements.
8. In designing office Buildings, the effect of vibrations on slabs must be analysed in accordance with the adopted codes.
9. If the average pre-compression exceeds three megapascal (3 MPa), the design Engineer must account for the consequences of shortening of the structural element in connection with the restraint of the structural element's supports.
10. Verification of Deflection Values:
 - To calculate long-term deflection, the following short-term incremental coefficients must be used:

Loading	Coefficients related to short-term elastic deflection value
Dead Load	3.0
Prestressing after losses	3.0
Live Load	1.5

- Pre-cambering in the PT slabs may be accepted provided that the designer gives a clear justification in accordance with the adopted code.
 - Cracked deflection (long-term deflection) must be within the allowable limits, taking into consideration the cracked section criteria.
11. The minimum horizontal spacing between metal ducts must be the greater value of seventy-five millimetres (75 mm) or the width of the channel.
 12. The use of curved tendons must be avoided as much as possible; and where required, anchorage must be used in addition to the top and/or bottom steel mesh, and the curving must not exceed 1:12
 13. Tendons may not be stopped inside the slab without supports at the end, such as drop or hidden beams, walls or columns, or any other special details.
 14. Jacking force must be compliant with the design code and must not exceed eighty (80%) of the breaking loads.

15. A bottom steel mesh of not less than T10 per 300 mm must be used to prevent the effect of shrinkage on concrete; and if the thickness of the slab is more than or equal to 300 mm, an upper steel mesh must be added in places where there is no steel bars on top, otherwise, the designer must take into account the shrinkage effect on the slab.
16. A minimum level of reinforcing steel bars must be placed above the supports to ensure mitigation of any cracks that could occur in these places.
17. Conventional reinforcement must be placed along the edges of all slabs. This must include U-bars laced with at least two longitudinal bars (top and bottom) as illustrated below:



18. All columns must be checked for punching shear using hand calculations or the relevant software approved by the DM. All columns must be provided with a minimum punching shear reinforcement steel bars to meet the ductility requirements for earthquake resistance.
19. Steel bars must be placed to resist stress concentration at cable ends. Spiral steel reinforcement, or any other approved detailing of the steel reinforcement, may be used.
20. Bottom steel at columns and support locations must not be less than thirty (30%) of the top steel used at the same location.
21. Theoretical (software generated) elongations of strands must be indicated in design drawings in a separate sheet. The accepted deviation between site recorded elongation and theoretical elongation must be within $\pm 10\%$, and must be inspected by the consultant and the specialist engineer.
22. The maximum allowable deviations in the location and height of the tendons are ± 5 millimetre in the vertical direction, and ± 100 millimetre in the horizontal direction.
23. Where there is a possibility of concrete cracking as a result of early shrinkage, it is recommended to apply two-stage stressing. The first stage is usually about twenty-five percent (25%) of the final prestress force, and is carried out as soon as the concrete

gains the required compressive strength for this stage, being between 10 MPa and 15 MPa. Sufficient site-cured cubes or cylinders must be provided to determine the compressive strength.

24. Where there is a possibility for post-tension tendon anchorage slip, an anchorage set loss value of six millimetres (6 mm) can be used for calculating the resulting set loss.
25. When stressing tendons for slabs or a system composed of prestressed secondary beams supported by primary beams, attention must be given to the sequence of stressing in order to avoid damage to the formwork of the primary beams.
26. At columns of two-way slabs, at least one duct consisting of two (2) strands must pass through the column or wall support; and if this is not possible, an additional bottom reinforcing steel bars must be placed in these areas. The quantity of steel must be equal to 1.5 times the minimum quantity required for flexural reinforcement but not less than $(2.1 b_w d / f_y)$, where b_w is the width of the column or wall on the side where the steel bars are placed. The reinforcing steel bars must extend after the wall width for a distance equal to or greater than the development length.

Soil and Foundation Investigation

Article (57)

1. Design Codes and Geotechnical Works:

Designs must be prepared in accordance with the latest American, European, or British codes of practice.

2. Soil Investigation

- 2.1 The European Code (Eurocode 7): Geotechnical design.
- 2.2 The British Standard Code of Practice (BS 5930): Ground investigations.
- 2.3 The British Standard Code of Practice (BS 1377): Methods of test for soils for civil engineering purposes.
- 2.4 The requirements and regulations of the local authority (the Emirates International Accreditation Centre).
- 2.5 The British Standard Code of Practice (BS 10175): Investigation of potentially contaminated sites.

- 2.6 ASTM International (formerly American Society for Testing and Materials).
- 2.7 The American Association of State Highway and Transportation Officials (AASHTO).
- 2.8 The International Society for Rock Mechanics (ISRM)

3. Excavations

- 3.1 The European Code (Eurocode 7): Geotechnical design.
- 3.2 The British Standard Code of Practice (BS 6031): Code of practice for earthworks.

4. Excavation Shoring

- 4.1 The European Code (Eurocode 7): Geotechnical design.
- 4.2 The British Standard Code of Practice (BS 8081): Code of practice for grouted anchors.

5. Piling Works

- 5.1 The International Building Code (IBC).
- 5.2 The European Code (Eurocode 7): Geotechnical design.

6. Geotechnical Works

- 6.1 Execution of Special Geotechnical Works

European Standards for Execution of Special Geotechnical Work:

- BS EN 1536 Execution of special geotechnical works –Bored piles
- BS EN 1537 Execution of special geotechnical works –Ground Anchors
- BS EN 1538 Execution of special geotechnical works – Diaphragm Walls
- BS EN 12063 Execution of special geotechnical works –Sheet piles walls
- BS EN 12699 Execution of special geotechnical works – Displacement piles
- BS EN 12715 Execution of special geotechnical works – Grouting
- BS EN 12716 Execution of special geotechnical works – Jet grouting
- BS EN 14199 Execution of special geotechnical works – Micro piles
- BS EN 14475 Execution of special geotechnical works – Reinforced fill
- BS EN 14490 Execution of special geotechnical works – Soil nailing
- BS EN 14679 Execution of special geotechnical works – Deep mixing

- BS EN 14731 Execution of special geotechnical works–Ground treatment by deep vibrations
 - BS EN 15237 Execution of special geotechnical works – Vertical drains
- 6.2 When construction activities, such as exploration, excavation, piling, shoring, foundations, and similar activities, are planned near protected road zones, the legislation regulating roads and public transport in the Emirate must be observed.

7. Geotechnical Requirements

The following geotechnical requirements and rules must be observed:

- 7.1 The soil investigation report and the geotechnical design of Buildings and other structures must be prepared by a qualified Geotechnical Civil Engineer licensed to practise the profession and approved by the competent department.
- 7.2 All designs submitted by the geotechnical Contractor (foundations and piling Contractor) must be approved by the consultant.
- 7.3 All soil investigation reports submitted by the geotechnical testing laboratory must be approved by the consultant. The consultant must witness and supervise the soil investigation process.
- 7.4 The specialist geotechnical Engineer must use the relevant approved technical software and must hold a valid licence to use the said software.

8. Geotechnical Design

a. Geotechnical Soil Investigation

1. General Guidelines for Soil Investigation:
 - 1.1 Soil investigation works and reporting must be carried out in accordance with the latest editions of the adopted codes, standards, and regulations; and in compliance with the requirements and bylaws issued by the competent local authority, namely the Emirates International Accreditation Centre (EIAC).
 - 1.2 Soil investigation must be carried out as required for the design and construction of the proposed project. This includes all physical and chemical tests on soil, rocks, groundwater, and other similar elements. The soil investigation laboratory must ensure that the geotechnical report provides sufficient information, including a clear definition of the geotechnical characteristics of the ground area under investigation. A soil investigation report must meet the following requirements, without limitation:
 - The report must include the standard penetration test (SPT) values, which must be obtained at 0.5 metre intervals for an initial depth of 3.0 m; and at 1 metre

intervals thereafter, unless a loose layer is encountered ($N < 10$). Where a loose layer ($N < 10$) is encountered, a continuous SPT must be conducted.

- Undisturbed core samples must be obtained in coreable cemented material, and unconfined compressive strength tests (UCS) must be performed on representative samples. The diameter of the core must not be less than seventy-six millimetres (76 mm) throughout the length of the core.
 - The general topography of the site must be indicated in the drawings, specifying all levels in the Dubai Municipality Datum (DMD) (this applies to boreholes, ground water level, and similar details).
 - All soil reports must be stamped and signed by a geotechnical Engineer who has sufficient experience and knowledge; is registered with the DM; and holds a bachelor's degree with an equivalency certificate from the Ministry of Higher Education.
- 1.3 All laboratories engaged for soil investigation must be licensed, accredited, and approved by the DM and the Emirates International Accreditation Centre (EIAC). The engaged laboratory must, in conducting soil investigations, comply with all the procedures and recommendations set out in the local regulations (EIAC), international codes, and/ or guides during the soil investigation process, and use appropriate sampling and extraction materials.
- 1.4 The soil investigation of any structure must be based primarily on the location of the structure, identified by specific coordinates as per the schematic map and geographical maps approved by the concerned entities, as well as the relevant information related to the magnitude of the superimposed loads, the number of Floors, the shape of the structure, previous land uses, topography, geological features, and surface water drainage.
- 1.5 The coordinates of the borehole sensor (x, y) as well as the levels indicated in the Dubai Municipality Datum (DMD) must be displayed on the site layout, and the site layout must reflect essential data, such as land plot boundaries, north direction, adjacent structures, traffic, utilities, vegetation, hazardous chemicals... etc.
- 1.6 The European Code (Eurocode 7) refers to the minimum number of boreholes, provided that there is a homogeneity between the soil samples extracted from the boreholes, as follows:
- For high-rise Buildings (G+12), at least one borehole must be dug for each seven hundred and fifty square metres (750 m^2), with a minimum of five (5) boreholes.
 - For lower Buildings comprising a ground level and less than twelve Floors, at least one borehole must be dug for each seven hundred and fifty square metres (750 m^2), with a minimum of three (3) boreholes.

- Sixty-metre (60 m) grids between boreholes are required in case of structures constructed on large areas.
 - For villa compounds, at least one borehole per villa must be dug.
- 1.7 The minimum depth of a borehole must extend below the level of the pile toe and the zone of influence of proposed foundations in accordance with the European Code (Eurocode 7) standards as follows:
- For pad and strip bases/foundations, the depth of the borehole must exceed the anticipated foundation level (usually between 2.5 and 3 times the width of the foundation) (with a depth of at least 8 metres for any borehole).
 - Drilling must be carried out at a greater depth at some points to explore and assess settlement conditions and possible groundwater problems in accordance with the recommendations of specialists in the field.
 - For raft foundations, the depth of in-situ tests or boreholes must be equal to or greater than the width of the base/ foundation, unless a bedrock is encountered within this depth.
 - In normal situations, exploration boreholes must be carried out below the stratum level of the ground that is not suitable for building foundations thereon, such as those with weak soil or compressible soil.
2. Minimum requirements for geotechnical report / soil investigation report
- The soil investigation report / geotechnical report is required to determine the extent and consequences of soil liquefaction or loss of soil strength, including estimates of differential settlement, lateral movement, reduction in bearing capacity, and any other geotechnical hazards. The soil investigation report must include:
- 2.1 design criteria, namely the type of foundations recommended; allowable bearing capacity; modulus of sub-grade reaction; and allowable settlement;
 - 2.2 a set of recommendations for addressing or mitigating the impact of certain problems that may arise, such as expansive soil, collapsible soil, soil liquefaction, soil settlement, and the impact of adjacent loads;
 - 2.3 various seismic parameters of the upper layer of the soil (30 metres high), according to the specified standards;
 - 2.4 piles working load capacity under compression and tension for different sizes and at varying depths and effective lengths, with all levels as set forth in the Dubai Municipality Datum (DMD);
 - 2.5 recommendations for pile foundation groups; and loads and settlement modification factors, where applicable;
 - 2.6 modulus of elasticity (Es) values;

- 2.7 horizontal soil sub-grade reaction modulus (K_h), and vertical spring constants (K_v);
- 2.8 constant of horizontal subgrade reaction (coefficient of subgrade modulus variation) (n_h) used in lateral pile analysis;
- 2.9 Poisson's ratio;
- 2.10 the stiffness and durability of group piles (K_s) and recommendations in case of pile group settlement, where applicable;
- 2.11 the optimum range of spacing between piles;
- 2.12 the soil parameters required for shoring systems and basement wall designs, such as bulk density, dry density, saturated density, shear resistance angle, cohesion, coefficients of soil pressure at rest (K_0); and coefficient of active and passive soil pressure for all soil layers;
- 2.13 soil classification, soil size distribution, and overall soil profile;
- 2.14 soil permeability;
- 2.15 a cross section of the soil passing through all the boreholes to provide information on various strata;
- 2.16 groundwater level, taken at the level prescribed by the Dubai Municipality Datum (DMD), and temperature;
- 2.17 Recommendations for the proposed design based on the groundwater level and calculations of the upward thrust of the maximum groundwater level;
- 2.18 results of laboratory tests on soil and groundwater samples for the presence and concentration of P.H, sulphates and chloride contents, or any other chemicals or components that may affect the integrity of the structure;
- 2.19 groundwater monitoring period and frequency (at least three (3) visits per week); and
- 2.20 any further information as per the guidelines of the European Code (Eurocode 7).

b. Open Excavation

1. General Guidelines for Excavation Works

- 1.1 Excavation works must be carried out in accordance with best construction practices, the European Code (Eurocode 7) "Geotechnical Design", and the British Code of Practice (BS 6031:2009) for excavation works.
- 1.2 The circular issued by the DM in respect of shoring of open excavation pits must be complied with.

- 1.3 Slope stability and durability calculations, or recommendations based on geotechnical parameters stated in the soil investigation inspection report, are required for all excavations deeper than 1.2 metres.
- 1.4 Materials used for backfilling purposes (maximum thickness of 2.00 metres) must consist of selected materials, such as sand, or granular mixture free from organic materials or deteriorating substances. The Plasticity Index of the backfill materials may not exceed ten percent (10%). The maximum particle size of backfill materials must not exceed seventy-five millimetres (75 mm), and the percentage of particles passing a 75-mm sieve must not exceed twenty percent (20%). The organic materials content must not exceed two percent (2%) and the water-soluble salt content must not exceed five percent (5%). The backfill materials must be placed in layers with a thickness of one hundred and fifty millimetres (150 mm) to two hundred and fifty millimetres (250 mm), and must be compacted to not less than ninety-five percent (95%) of the maximum dry density. Specialists must state whether or not the material available in site can be used for general backfilling after performing the necessary analysis. Sand cone test can be carried out to determine the degree of compaction, whereas the plate load test (as per ASTM D1194 -94) is also an acceptable test to confirm that the bearing capacity corresponds to the allowable settlement.
- 1.5 Protection must be provided to all existing utilities at all times.
- 1.6 All open slopes must be constantly monitored, and relevant observations must be recorded.
- 1.7 All excavations must be kept dry at all times, and slopes must be protected from adverse weather conditions that may affect them.
- 1.8 All excavation activities must be carried out within the designated plot limits, keeping a distance of at least one metre (1 m) from the edges of the excavation as a restricted area in which vehicles are not allowed to park. For any excavation works required outside the designated plot limits, the Contractor must obtain all required approvals from all concerned entities and all owners of neighbouring land plots before the commencement of such works.
- 1.9 All health and safety precautions must be taken at construction sites during the implementation of excavation works.
- 1.10 Shoring systems must be used in all excavation operations deeper than two metres (2 m).

c. Shoring Systems

Shoring systems are temporary structures that are designed to perform satisfactorily for a maximum period of two (2) years.

1. General Guidelines for Shoring:

- 1.1 Necessary protection must be provided to all existing utilities at all times.
- 1.2 All shoring activities must be carried out within the designated land plot limits only. As for any shoring or anchoring works outside the limits of the designated land plot, the Contractor must obtain all required approvals from all concerned entities and all owners of neighbouring land plots prior to the commencement of such works. The uppermost two (2) metres (roads/services side) of any shoring system outside of the plot limits must be removed once the work of the basement wall is completed.
- 1.3 Shoring systems are not considered part of the main structural system.
- 1.4 The Contractor must, in coordination with the consultant, maintain on site at all times a record of actual deflections and other parameters, using inclinometers or similar devices.
- 1.5 All shoring works must be constantly monitored and followed up by the Contractor and consultant.
- 1.6 The movement of heavy equipment, loading, unloading, and storage of materials must be controlled at the site, so that they may not in any way impair the structural stability and durability of the shoring system.
- 1.7 Removal of anchors must be carried out on site, only after obtaining the written consent of the consultant.
- 1.8 The main Contractor, the shoring Contractor, and the consultant must appoint experienced and specialised geotechnical Engineers to supervise the work site.
- 1.9 Peak groundwater levels must be verified throughout the design life in order to cope with natural variations, such as the peak tide, and land use changes, such as groundwater level rise due to irrigation or global warming; and to ensure that the robustness and durability of the retaining wall are not affected.
- 1.10 The depth of the shoring anchors and internal excavation must be verified to ensure adequate factor of safety against ground heave; avoid the possibility of groundwater flowing into the excavations; and ensure compatibility between the shoring system design and groundwater dewatering mechanism. The shoring Contractor, the main Contractor, and the consultant must review the dewatering system design developed by the concerned specialists to ensure that the design is compatible with the design of the shoring system; that the wall deformations are

within allowable limits, and that the dewatering system does not affect adjacent structures and infrastructure.

2. Shoring System Design

For the different excavation depths and the conditions and nature of the site, the details set forth in the Table below must be observed:

Excavation Shoring System Type	Excavation Depth Measured from the Ground Level
All types	Up to 5 metres depth, or one basement
All types except for H-piles	More than 5 metres depth – in cases where there are no buildings in the adjacent land plot or water bodies
Watertight shoring system	In cases where there are buildings on the adjacent land plots and a high groundwater table
Watertight shoring system	Projects located near water bodies

- An excavation shoring system other than those mentioned above may be recommended based on the soil investigation report; the groundwater level; and the existence of water bodies, adjacent buildings, and surrounding utilities.
- All shoring design works at projects comprising four (4) or more basements, special projects, and projects close to water bodies must be reviewed by a third-party geotechnical consultant.

The following additional instructions must be complied with:

Minimum surcharge loads	A minimum surcharge load of 20 KN/m ² must be observed for roadsides and for neighbouring plot sides. Depending on the existing site conditions, the minimum surcharge load on shoring walls from the road or adjacent plot side can be increased, based on the actual calculations, in case of existence of adjacent foundations.
Minimum spacing of anchors	1.2 m
Maximum grout length for anchors	10 m

Minimum grout length for anchors	3 m
Maximum lateral displacement	The maximum allowable lateral displacement of shoring systems is 40mm.
Unplanned Excavation	In checking the stable equilibrium and soil deformation, retaining walls must be designed assuming a depth of unplanned excavation in front of the wall not less than 10% of the total height retained for cantilever walls or 10% of the height retained below the lowest support level for propped or anchored walls. The minimum depth of unplanned excavation is 0.5 m.

3. **Shoring Works Near Water Bodies**

The following guidelines must be followed in implementing shoring works for projects that are near water bodies:

- 3.1 All shoring works must be designed as independent structures. The existence of a quay wall must not be considered during the design of shoring works.
- 3.2 The positions of anchors must be away from the quay edge.
- 3.3 Designs of shoring and piling works for projects located near water bodies must be provided.
- 3.4 All projects located near water bodies must have watertight shoring systems, such as diaphragm walls or secant piles.
- 3.5 The shoring systems must be discussed, and final decisions in respect thereof must be made, during the preliminary submission stage.
- 3.6 All temporary works must be clearly defined, and a method statement must be issued by the main consultant. The Contractor must undertake to implement all the works included in the method statement only after obtaining the written approval from the main consultant.
- 3.7 All shoring design works near water bodies must be reviewed and approved by a third-party geotechnical consultant, who will be jointly and equally liable for the shoring design with the consultant and the Contractor carrying out the shoring works.
- 3.8 The Contractor carrying out the shoring works, main Contractor, and the consultant will be fully liable for any unsafe performance of the site enabling and shoring works, and will be subject to legal liability for the same.

3.9 All shoring works of sites that are near water bodies must be continuously monitored by the Contractor and the consultant; and any corrective action must be subject to obtaining the relevant prior approval of the competent authorities.

3.10 All parties must agree to the safety plans developed based on the individual and independent risk assessment for the temporary works near water bodies.

d. Ground Improvement

1. General Guidelines for Ground Improvement

1.1 The design for the ground improvement process must be prepared by a specialist Contractor, and reviewed and approved by the consultant.

1.2 Laboratory tests must be conducted on representative samples. The laboratory must submit an official letter confirming the indicated laboratory results of soil bearing capacity and improved soil properties.

1.3 All tests that must be performed after soil improvement must be illustrated in the drawings during the design phase.

1.4 The soil report submitted must be based on the tests carried out after the soil improvement process.

1.5 All Contractors and consultants must assign the supervision of the site to specialised and experienced geotechnical Engineers.

1.6 All excavation activities must be carried out within the designated land plot limits only. For any excavation works carried out outside the limits of the land plot, a no-objection letter must be obtained from the concerned authorities or the owners of adjacent land plots prior to the commencement of those works.

1.7 All health and safety precautions must be complied with while carrying out excavation works.

2. Liquefaction

Evaluation of likely liquefaction hazard must be carried out by a competent and qualified geotechnical Engineer. The evaluation must be based on the results of an adequate number of field tests (preferably CPTU). Where the analysis indicates significant liquefiable zones, then further deep compaction will be recommended for the site or part thereof. Where minor localised potentially liquefiable zones within limited depth are indicated, then it is important to assess the likely induced effects such as:

2.1 liquefaction-induced settlement of surface foundations;

2.2 surface manifestation;

- 2.3 loss of bearing strength of surface foundations; and
- 2.4 loss of lateral and vertical stiffness of piles.

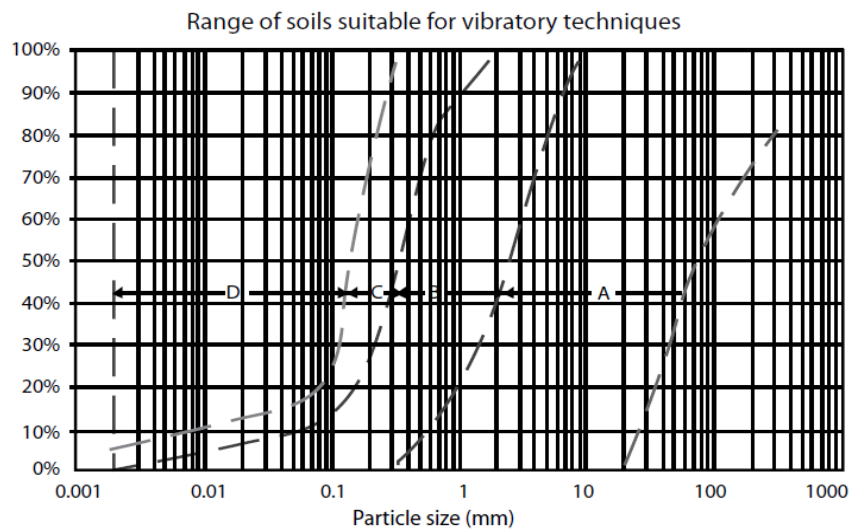
3. Calculation Theory

- 3.1 Recommended Procedures for Implementation of DMG Special Publication – 117 Guidelines for Analysing and Mitigating Liquefaction Hazards in California, Implementation Committee, March 1999, must be implemented.
- 3.2 Cyclic stress ratio (CSR) induced in the soil due to earthquakes, and other soil settlement coefficients, will be calculated as per the structural requirements for seismic loads prescribed by Article (54) of this Bylaw.
- 3.3 Cyclic resistance ratio (CRR), representing soil “strength”, must be calculated based on in-situ test data from Soil Penetration Test (SPT) and Cone Penetration Test (CPT) (1996 NCEER workshop on Liquefaction Evaluation).
- 3.4 Liquefaction potential will be evaluated by calculating the factor of safety against liquefaction for specific seismic load and soil strength, provided that the factor of safety is less than 1.25 ($F.S. = CRR / [(1.2-1.5) CSR]$);
- 3.5 The groundwater table for liquefaction analysis must be selected based on the peak level throughout the design life, allowing for natural changes (e.g. peak, spring, tide) and land use changes (rise in groundwater level due to green area irrigation or global warming).
- 3.6 For CPT-based liquefaction analysis, soil profiling will be conducted according to Robertson 1996 in order to highlight the localities of high fines content. Standard Penetration Test (SPT), or similar methods, must be used in liquefaction analysis. Where soil liquefaction is analysed using a software, a valid copy of the software licence and the updated instruction manual must be submitted.
- 3.7 Amplification factor and shell correction factor must be calculated based on the soil type and classification.
- 3.8 Liquefaction may be calculated using any method adopted in the codes referred to herein.

4. Soil Improvement Techniques

- 4.1 The techniques of soil improvement through liquefaction mitigation include densification, drainage, soil reinforcement, grouting, soil replacement using Vibro stone columns, deep dynamic compaction, and any other adopted techniques prescribed by recognised codes or standard specifications.

4.2 Range of soil (particle size-sieve analysis) suitable for vibratory techniques are zoned in the Figure below:



Zone A: The soils of this zone are very well compactable. The right borderline indicates an empirically found limit where the amount of cobbles and boulders prevents compaction because the vibroprobe cannot reach the compaction depth.

Zone B: The soils in this zone are suited for Vibro Compaction. They have fines content of less than ten percent (10%).

Zone C: Compaction is only possible by adding suitable backfill (Material from zones A or B) from the surface (stone columns or sand columns).

Zone D: Stone columns are a solution for a foundation in these soils. There is a resulting increase in bearing capacity and reduction on total and differential settlement.

e. Piles

1. Design Requirements

In designing piles, all the requirements set out in the table below must be complied with:

Permissible crack width for tension piles	Cracks resulting from groundwater uplift forces = 0.1 mm Load cracks caused by secondary stresses earthquake and wind = 0.2 mm
Geotechnical Design Parameters	Must be compatible with the recommendations included in the geotechnical soil report
Materials testing reports (aggregates, steel, concrete, etc)	Must be conducted by laboratories accredited by the DM or the EIAC in Dubai.

Minimum design of lateral force	Minimum of 5% of the pile capacity
Minimum Reinforcing Steel (Rebar)	To achieve ductility at 0.5%, reinforcing steel must be provided for the full length of the piles. Minimum stirrup diameter must be 10 mm for all the piles.
Piles Design	• In pile design, horizontal and vertical forces must be considered. • Verticality (1/75). • Out of position (7.5 cm). • Piles must be designed with a minimum safety factor of 2.5 unless a geotechnical study and site inspections are conducted by a geotechnical consultant. • Pile skin friction in sand must be reduced in case of using Bentonite as drilling slurry.
Pile Spacing	In the absence of a pile centre-to-centre study, piles spacing must be at least 2.5 times the pile diameter.
Stresses	The permissible service stress must not exceed 25% of the concrete compressive strength (F_{cu}) of specified cube at 28 days
Lateral Stiffness of Supports	50% to 100% of the pile vertical stiffness Other percentages may apply (such as 10% to 15% of the vertical pile stiffness) subject to submission of the relevant geotechnical studies, including the assessment of lateral pile group effect, conducted by a geotechnical consultant in compliance with the relevant adopted code.
Pile Vertical Stiffness	The pile group settlement effect on vertical stiffness and foundations must be assessed.

- A representative (a specialist geotechnical civil Engineer) of the main consultant and specialist Contractor must be available at the site.
- The requirements relating to the minimum design lateral force and out-of-position moment, as set out in the above table, may be ignored subject to observing the following:
 - a. thermal impact on the Building foundations or raft in case of exposure to seasonal temperature changes;
 - b. the piles group effect on designing the piles and the Building;
 - c. the moments resulting from the raft dishing effect on designing piles;

- d. seismic kinematic interaction analysis effect on designing piles;
- e. lateral stiffness of the soil surrounding the foundations and basements;
- f. where out-of-position moments are ignored, the pile location approved design must be followed. Where there is a discrepancy between the approved pile locations and the actual pile locations (as built), the geotechnical and structural models must be updated to reflect the actual pile locations. A piles reaction analysis must be conducted to assess the effect of the in-situ pile locations, and the necessary amendments to the raft foundations design must be made.

2. Pile Testing Minimum Requirements

Pile testing must conform to the minimum requirements set out in the table below:

Static Load Test	1% for each pile diameter
Dynamic Load Test	5%
Sonic Test	10%
Integrity Test	100%
Cubes Test	As per specifications
Steel Test	As per specifications
Preliminary Test Pile (PTP)	Single test for the longest pile with the largest diameter and the heaviest load.

3. Preliminary Test Pile (PTP)

The main consultant and the specialist geotechnical Contractor are responsible for selecting the PTP location so that it may not affect the proposed permanent pile locations of the main structure. The PTP must be submitted at the designing phase, and the proposal must include:

- detailed drawings illustrating the locations of the test piles;
- information on the PTP schedule and plan; and
- A formal cover letter from the main consultant and/or the specialist geotechnical Contractor.

In addition to the above requirements, and as stipulated in the European Code (Eurocode 7), the safest values of the following findings must be used in making design calculations:

- the findings of the Preliminarily Test Pile (PTP);

- soil investigation laboratory recommendations; and
- the calculations submitted by the consultant or the specialist geotechnical Contractor.

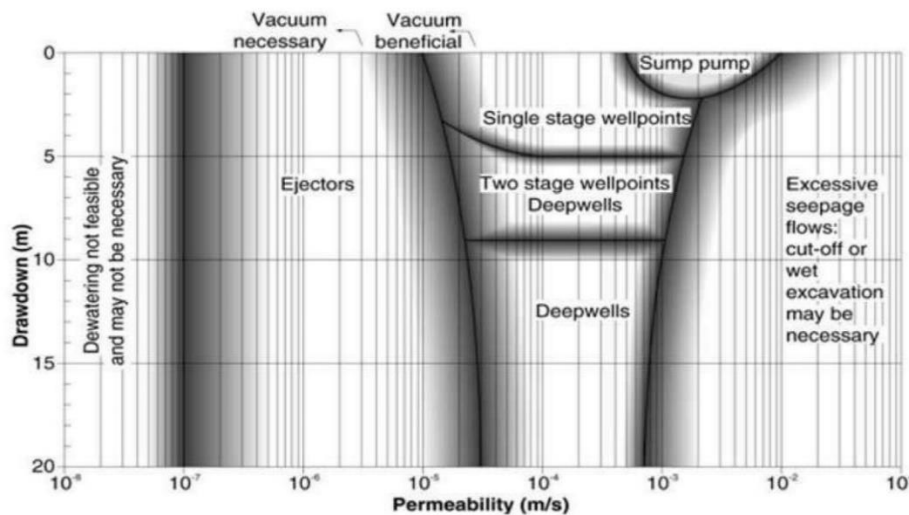
The PTP findings may be used in designing piles and raft foundations, as stated in the European Code and the International Building Code.

f. Dewatering

1. Necessary protection must be provided for all existing utilities at all times.
2. The dewatering system must be based on preventing the loss of fine particles from the soil (loss of fines) and any impact on adjacent structures.
3. A hydrogeological model must be prepared for at least twenty (20) metres below the bottom of the excavation. The model must determine the type of soil and rocks, horizontal permeability of each layer, incoherent or gypsum soils, and other areas exposed to water leakage under the surface.
4. A dewatering design and a general plan must be developed through digital modelling to reduce the dewatering pressure in line with the depth of the shoring system and excavation, to ensure an adequate safety factor against soil heave.
5. The areas at risk of subsurface hydro-geologic deposits must be identified.
6. A groundwater/ piezometric pressure monitoring bore network separate from the dewatering/ depressurisation bore system must be set up to monitor vertical groundwater gradients, horizontal groundwater gradients, and water elevations inside and outside of the excavations and shoring system.
7. Dewatering must not be suspended without obtaining the prior written consent of the main consultant and verifying that balance is achieved between the groundwater pressure and the weight of the structure, with a safety factor of not less than 1.1 against uplift subject to ignoring the friction between walls and soil.
8. Care must be exercised during dewatering to ensure that the fines content of the soil is not removed during pumping, as this could result in unpredicted settlements of the surrounding ground and associated structures.

g. Ground and Water Pressure Loads

1. For basement or sub-structures and when checking for the uplift of the structure, the soil for a depth of at least one metre (1 m) from the existing ground level must be ignored in the computations, and a minimum safety factor of 1.1 must be used in the design for uplift when taking dead load.



2. Tidal weather seasonal variations and the existing water level at the area must be taken into account in estimating groundwater level.

Issuing Implementing Instructions

Article (2)

The Executive Director of the Engineering and Planning Sector of the DM will issue the instructions required for the implementation of the provisions of this Resolution.

Repeals

Article (3)

Any provision in any other administrative resolution will be repealed to the extent that it contradicts the provisions of this Resolution.

Publication and Commencement
Article (4)

This Resolution will be published in the Official Gazette and will come into force on the day on which it is published.

Dawood Abdul Rahman Al Hajiri

Director General

Dubai Municipality

Issued in Dubai on 22 February 2021

Corresponding to 10 Rajab 1442 A.H.