International Labour Organization

Better Work Jordan Programme

Enhancing the Structural Integrity of Dormitory Buildings in Jordan's Garment Sector - Phase II

Standards for Rectification of Defects in Existing Dormitory Buildings and Design of New Dormitory Buildings

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engicon

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1. Executive Summary

The "Standards for Rectification of Defects in Existing Dormitory Buildings and Design of New Dormitory Buildings Report" is the fourth and last task assigned to Engicon, under Phase II of Better Work Jordan's (BWJ) project "Enhancing the Structural Integrity of Dormitory Buildings in Jordan's Garment Sector".

Stemming from the belief that decent living conditions are a right to all workers, and that it is directly proportional with raising their productivity and as a result benefit the business as a whole, the project aims to set guidelines related to assessing and mitigating defects against certain health and safety measures within existing dormitories, as well as develop design regulations related to building new dormitories in the future, to ensure surpassing previously identified defects which can form risks to the health and safety of inhabitant workers.

So, in order to prepare this report, Engicon team poured their experience and investigated variable national and international standards and codes, with special concern related to design implementations highly affecting the safety and health of workers living in dorms, and highlighted typical defects identified in task one, and studied the accompanied risks of each defect as illustrated in task two, to develop a guideline for rectification of existing dorms or building new, with relevance to the suggested repair works, improvements, corrective actions included in task two, and relating to four main occupational safety and health (OSH) measures: Structural Integrity, Fire Safety, Electrical Safety and Public Health.

This report can be used as a reference for designing a new dormitory building, that complies with all regulations and addresses all OSH measures; starting from the site selection, to the planning and layout, and the MEP recommended systems or needed installations, to Interior design requirements or preferences (related to Dimension, Finishing Materials and Furniture).

2. Abbreviations

2.1. List of General Abbreviations and Acronyms

BWJ	Better Work Jordan Programme
EHS	Environmental Health and Safety
GoJ	Government of Jordan
HC	Handicapped
HR	Human Resources
IEQ	Indoor Environment Quality
ILO	International Labour Organization
JEA	Jordan Engineers Association
MoH	Ministry of Health
MoL	Ministry of Labour
MoPWH	Ministry of Public Works and Housing
OSH	Occupational Safety and Health

2.2. List of Technical Abbreviations and Acronyms

AC	Air Conditioning
ACI	American Concrete Institute
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BS	British Standards
CCTV	Closed-circuit television
DB	Electrical Distribution Board
FACP	Fire Alarm Control Panel
FFL	Finish Floor Level
FR	Fire Rated
HVAC	Heating, ventilation, and air conditioning
IBC	International Building Code
ICC	International Code Council, Inc
ID	Interior Design
IRS	Internal Responsibility System
JBC	Jordanian Building Code
LPG	Liquefied petroleum gas
MEP	Mechanical, Electrical and Plumbing
NFPA	National Fire Protection Association
RCD	Residual Current Device
UBC	Uniform Building Code
WC	Water Closet

3. Introduction

The Better Work Jordan Programme (BWJ) brings together stakeholders from all levels of Jordan's garment manufacturing industry to improve working conditions, enhance respect for labour rights, and boost the competitiveness of the sector.

Factories participating in BWJ are monitored and advised through factory assessments, advisory visits, and training services.

The programme aims at improving the provision of safer working conditions, especially around occupational safety, and health across manufacturing enterprises across Jordan.

A key object of this programme is to demonstrate that good working conditions and decent technical investment can help make factories and their satellite units become more productive.

From all the above descended the project "Enhancing the Structural Integrity of Dormitory Buildings in Jordan's Garment Sector".

3.1. Assigned Tasks

Engicon was assigned to complete four main tasks related to the "Enhancing the Structural Integrity of Dormitory Buildings in Jordan's Garment Sector" Project:

1. Prepare a Typical Defects Identification Report.
2. Provide guidance for assessment and repair of typical defects report.
3. Set a methodology for identification of other non-typical defects.
4. Suggest standards to be used for rectification of defects in existing dormitory buildings and design of new dormitory buildings. (Which this report represents)

3.2. Project Main Objectives

The project aims at achieving the following four main objectives:

- Awareness raising among factory owners on typical building safety requirements.
- Guidance to identify safety defects and the level of expertise needed for rectification.
- Identification of national codes requirements for dormitories.
- Identification of safety issues not covered by national codes, with reference to international good practices.

4. References

In order to prepare this report, titled "Standards for Rectification of Defects in Existing Dormitory Buildings and Design of New Dormitory Buildings", Engicon team poured their experience and investigated variable national and international standards and codes relating to certain occupational safety and health measures. (*)

4.1. OSH Related Documents and Procedures

Comprehensive guide - MoL - Work procedures for safety and health prevention measures to limit the spread of the corona virus
Dormitories Inspection/Assessment Guide (Jordanian MoL, MoH, BWJ)
The Public Health Law

4.2. National and International Technical Codes and Standards

National Fire Protection Association (NFPA)
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
Jordanian National Building Codes
British Standards
American Standards
2015 International Building Code® (IBC), by the International Code Council, Inc (ICC)

4.3. Operational Safety and Health Measures

In order to come up with a practical distribution for the list of requirements or needed design implementations in any dormitory building, the following four main OSH measures were highlighted; and under each measure, certain points are considered:

- Structural Integrity
- Electrical Safety
- Fire Safety
- Public Health

(*) For illustrations related to references, Local and International Codes and Standards used, check Annex A (List of References) attached to this report.

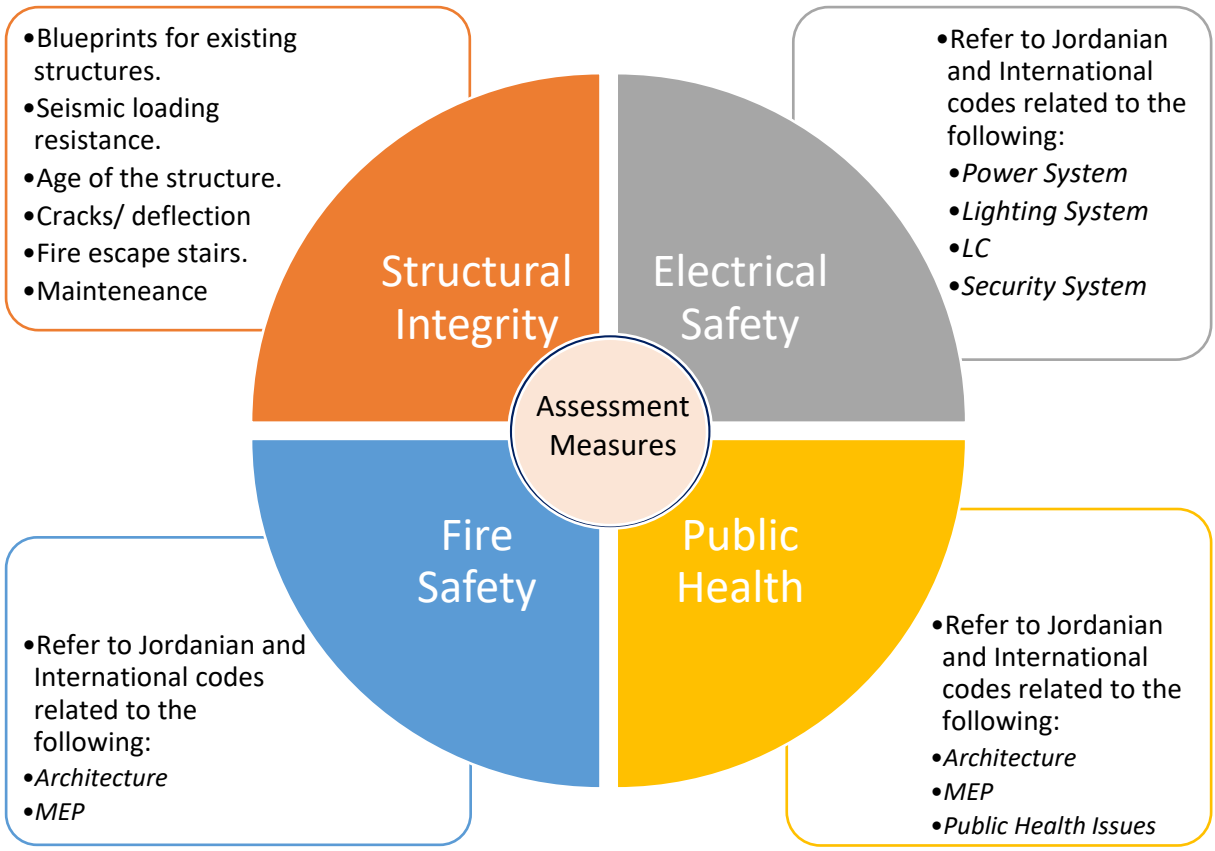


Figure 4-1: Assessment Measures related to OSH in Dormitories

The previously listed measures are to be considered during the assessment procedure of any existing dormitory building or for designing any new dormitory building.

Note

Related to the assessment criteria and methodology suggested for the identification of defects in existing dormitory buildings, refer to task one report "Identification of Typical Defects", and task three repot "Methodology for Identification of Non-typical Defects".

As for the guidance related to repair works and suggested rectification or corrective actions, with relevance to the severity of accompanied risks, refer to task two report "Guidance for Assessment and Repair of Typical Defects".

5. Design Guidelines for building new dormitories

5.1. General

This section forms the baseline for the design guideline for dormitory buildings in Jordan based on the minimum requirements extracted from national and international building codes and international best practices.

The following mainly includes instructions/standards related to designing new dormitory buildings that complies with all safety and health measures, starting from the planning stage to the general layout, and conceptual design to the detailed design and finishing.

In the following sections reference numbers will be indicated:

*(#): reference number to Local and International Codes and Standards used, as indicated in Annex A (List of References) attached to this report.

**[#]: reference number for (Subject of Assessment) in the checklist proposed within section 7 (Applications) included in Report 3 for the same project; titled "Methodology for the Identification of Non-Typical Defects Report".

5.2. Planning Section

5.2.1. Site Selection Criteria

The Site Selection proceeds the design activities related to any dormitory building, and to ensure compliance with OSH measures, the following points should be considered:

- Locate the building on street or streets or on a clear empty space wide enough for Fire engine to access the site in case of emergencies. *(61)**
- The dormitory must be at least 500 meters away from any sources of pollution or noise, including for example, carbon monoxide, sulphur dioxide, nitrogen oxides or exhaust emissions; sewerage systems; wastewater; and noise pollution. [1] ***(70)**
- Site is not to be on a flood area or hazardous water area.
- Select site which has potential for future expansion.
- Site allows design to incorporate daylight for interior/exterior spaces and capitalize on direct sunlight through shading elements.
- Topography, property line obstructions, and vegetation should be considered.

5.3. Design Section

5.3.1. Site Planning

This section addresses the site planning after a site has been selected.

5.3.1.1. Site planning overview:

- Respect surrounding environment (colors, materials, landscaping, height, etc.).
- Locate building to maximize environmental factors (i.e., sun, wind, acoustics, etc.).
- Minimize crossing vehicular traffic routes to ensure pedestrian circulation safety to the dormitory. (Make sure pathways leading to the site are secured and safe.)
- Locate buildings so that supervision site-lines are provided for outdoor areas.
- Locate dormitory away from electrical transmission lines.
- Design the building(s) location on a well-drained and elevated area.
- Ensure that site bearing capacity can support loads of future vertical and horizontal building expansion.
- Location to be away from loud machinery noises.
- To be away from chemicals, smokes, gases produced in the workspace or any source of pollution. The dormitory must be at least 500 meters away from any source of pollution, including carbon monoxide, sulphur dioxide, nitrogen oxides or exhaust emissions; sewerage systems; wastewater; and noise pollution. *(70)*

5.3.1.2. Site analysis

The design team shall visit the site and conduct due diligence as follows:

- Verify the exact location /correct site address (with reference to official land deeds).
- Conduct an assessment to confirm the following:
  - The site area is sufficient for the required building gross floor area, assembly area within the maximum permitted number of stories. (Considering the estimated occupancy rates) (noting that the assembly area connected to the exits should be sufficient to accommodate all building occupants, taking into account that a min. of 0.30sq.m. should be provided per person.) *(57)*
  - The extent of earthwork is cost effective for obtaining site slopes for grading and foundations suitable for level areas for the building pad and any outdoor activities.
- Prepare a new topographic and boundary survey of the site (existing surveys are not sufficient) that combines all the required data on one drawing (including surrounding streets, accessibility routes, existing structures, MEP services, infrastructure, telephone and electrical poles, trees…etc).
- List general climate and local conditions that includes monthly temperatures, humidity, rainfall figures, together with sun path, critical wind speeds and directions.
- Identify views from site, neighboring developments (existing and potential), vegetation to preserve, and surface water drainage routes (for potential groundwater recharge pits). Photograph the site and its surrounding areas. (This affects design decisions related to openings within external facades of the building, since any opening is to preferably oppose a nice view)
  (71)

5.3.1.3. Site Layout / Building Massing Orientation

Begin the design process with conceptual site layouts/options, addressing the following:

- From the space program gross area, show concept sketches illustrating the "footprint" of required ground level spaces. Show zoning of interior areas along with outdoor parking, guard room, and pedestrian/vehicular site entrances.
- Locate the Assembly area to be connected to building exits.
- All site storm drainage shall slope away from the building and shall drain by gravity.
- Avoid removing and cutting healthy trees.
- Fit the master plan to allow for future expansion.
- Position the building masses relative to topography and cut-and-fill of contours, with priority to building orientation.
- Plot the optimum orientations for different functions and windowed facades with relevance to site analysis related to climate, orientation, wind direction and sun path. (See the figure to the right)

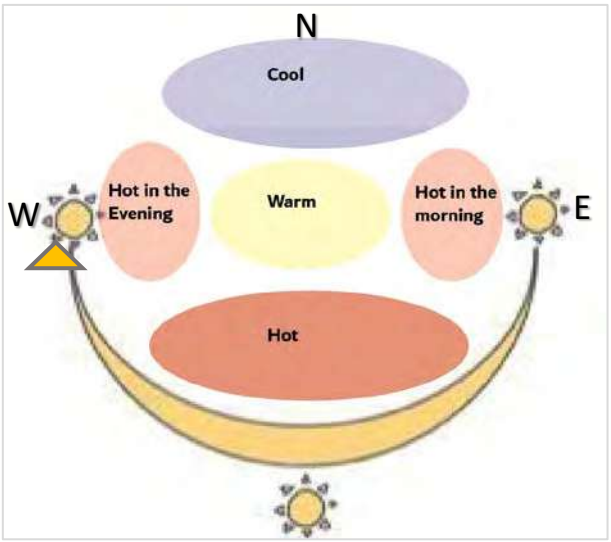


Figure 5-1:Daily range of temperature conditions in Jordan

- Abide to minimum requirements related to distances from electrical power supplies columns or cables which may cause injury due to electrical shock, fire, or electrocution, as shown in the table below. *(70)*

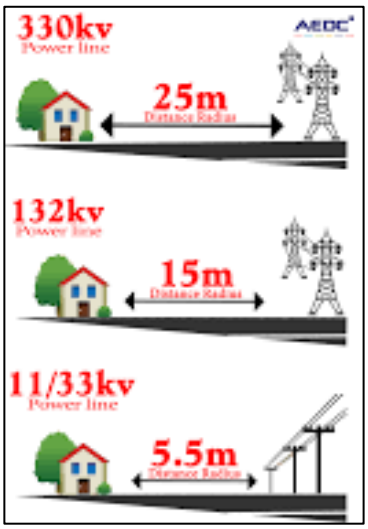


Table 1: Minimum Distances between building and Electrical Poles

Circuit Voltage	Pole	Tower (pylon)
11 kV to 33 kV	2 m	6 m
Exceeding 33 kV to 66 kV	6 m	9 m
Exceeding 66 kV	8 m	12 m

5.3.2. Dormitiry Building Planning

This section addresses building planning considerations.

5.3.2.1. Objectives for the Design of Dormitory Facilities

The following are the fundamental design objective of dormitory buildings:

- Improve the working and living conditions of workers, which will consequently increase their productivity and generally benefit Jordan's garment sector.
- Enhancing the safety and public health conditions of dormitory buildings in Jordan.
- The Dormitory Building Design shall satisfy requirements related to the four main previously identified OSH measures: Structural integrity, Fire safety, Electrical safety and Public health.
- The dorms must offer workers sufficient privacy:
    - Women's dormitories are preferably to be separate from those for men.
    - Privacy between members within the household to be provided.
    - For the members of the household, privacy is to be guaranteed against undue disturbance by external factors.

5.3.2.2. Future Expansion

When planning a new dormitory, consider future expansion and extensions to avoid overcrowding and to keep the space organized, clean, healthy and maintained as per its original designed function and layout, limiting undesired layout changes in the future.

5.3.2.3. Accessibility

- Ramps to be provided at entrances to serve the handicapped people. [1] *(02)*
- Vehicular Access to be provided (specially for Civil Defence Vehicles) *(61)*
- Protected and Safe pedestrian pathways within and towards the facility.

5.3.2.4. Space program

The following are the main spaces which are to be included in the dormitory building:

- Sleeping Rooms (including 1 Sleeping Room for disabled people, provided with a handicapped toilet in adjacency)
- Sanitary facilities (toilets, showers, changing rooms, washing areas)
- Kitchen / Cooking Area
- Dining Hall / Canteen / Cafeteria
- Laundry area (In addition to an outdoor space for hanging wires/ drying clothes)
- First Aid/ Clinic
- Services (Electrical Room, Boiler Room (if needed) and Storages)
- Administration department
- Outdoor assembly area, Landscape and Green Areas

- Recreational areas (either included within the dormitory buildings or in adjacency): Including social/rest spaces (ranging from multipurpose halls to designated areas for radio, TV, cinema or else) and recreational facilities (ranging from exercise equipment to a library, swimming pool, tennis courts, table tennis, educational facilities) [2]

(*) Optional spaces, Indoor activity such as a library, cinema, tv room. Etc
(**) Assembly area in emergency cases / outdoor activity areas (such as a football, basketball court)

(***) Disabled room at ground floor level with handicapped toilet beside it

(****) Boiler room according to the design requirements

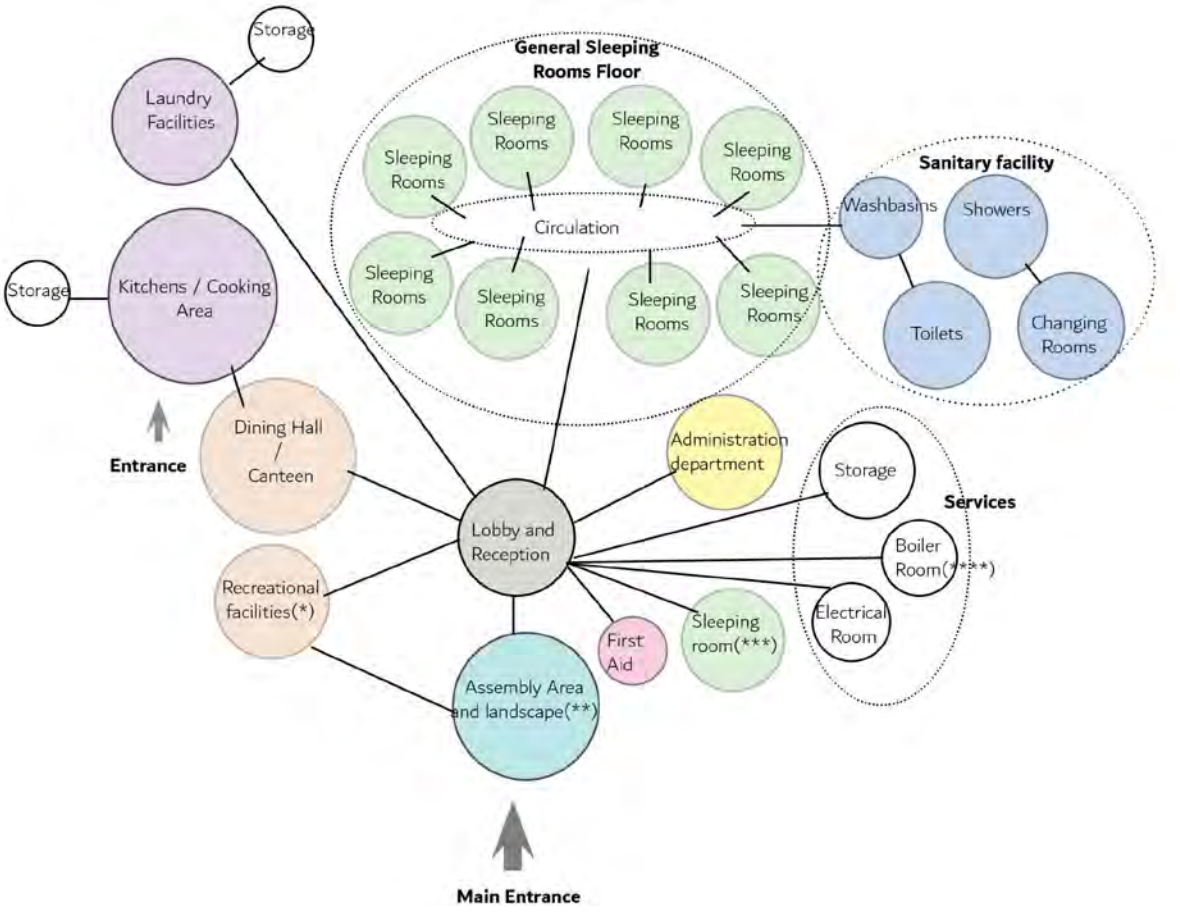


Figure 5-2: Zoning Bubble Diagram

5.3.2.5. Building area, setback and height

Building area and height should be determined according to the number of workers (estimated capacity load), in addition to following the area/plot regulation (official land deeds provided by governmental authorities, showing maximum allowed built-up area, footprint, setbacks and building height).

In general, the maximum height allowed of the building from the main entrance level is 4 stories if an elevator is not provided. [3]

All independent workers' dormitories shall be sufficiently set back from the road and common boundary. The setback distance is measured from the road reserve line or boundary line to the external wall of the buildings, excluding land to be vested to the State for road or drainage or public purpose.

All independent workers' dormitories fronting a public road shall provide a road buffer, the width of which depends on the hierarchy of the road. A green buffer shall be set aside in the road buffer depending on the width of the road buffer. [4]

6. Design Requirements Satisfying Basic OSH Measures

6.1. Structural Integrity

6.1.1. General

For Existing Structures, visual inspection can be applied ensuring the following:

- Shape Regularity existence of reinforced concrete shear walls (ex: Reinforced concrete staircases or any individual shear wall) and integrity to resist the seismic loading. *(25, 26)*
- Compliance to as Built drawings (stamped copies and original design calculations) with no variation to spans between columns, functions of rooms, or applying additional loads (dead or live loads) over different structural elements. *(23,27,28,29)*
- Check of all internal structural elements (Slabs, Beams, Columns, etc…) and external site structures (Stairs, Retaining walls, Concrete tanks, etc…).for seen cracks, concrete spalling, reinforcing bars corrosion, steel structures dimensions, welding, and connections. *(31,32,33,35,38)*
- No settlement in ground slab on grade and differential movement across expansion joints (if any) or column / foundation settlement. *(36)*
- Check of roof floors insulation and any damage in the concrete or structural elements due to water leakage. *(30,37)*
- Ensure periodic maintenance for structural elements. *(24)*

For new constructions, safety, adequacy, and integrity of the structures will be achieved through selection of adequate section properties and parameters of reinforced and plain concrete with sufficient steel reinforcement and / or structural steel sections for different structural members (Slabs, Walls, Columns and Foundations) to achieve the required capacity of the applied loads in accordance with adopted design codes.

In this section, the most important structural requirements will be elaborated to guarantee the best design guidelines for the dormitory buildings in Jordan.

6.1.2. Required Structural Design Documents

Before the design and / or construction of any structure, the following documents must be presented for the engineers, to ensure the best design and construction results.

6.1.3. Structural Design Methodology

The standards and requirements that will be mentioned in the structural integrity section are applicable to conventional concrete and structural steel of regular buildings, and structures. And set forth as minimum standards, the designer may propose more conservative criteria if in his judgment, such criteria are required.

The structural design criteria (Methodology) must contain:

- The structural scope of work.
- Used local and international codes and standards.
- Description of the site condition and the important geotechnical data.
- All the applied loadings that will affect the structure with the used loads combinations (as per codes).
- Properties of all used materials (concrete, rebars, steel, etc).
- Special requirements for the best design of structural elements (deflections, crack widths, control joints, etc).
- Structural design software.

6.1.4. Structural Design Drawings

The structural design drawings must include:

- General structural notes and details (corresponds with the criteria).
- Foundation framing layout plan.
- Detailed sections in all foundations.
- Columns and Shear walls layout plans for all floors.
- Columns and Shear walls reinforcement details and schedules.
- Structural details of stairs and cores.
- Slabs framing layout plans.
- Beams details.
- Any other structural details (site plan, details of site structures, boundary or retaining walls, etc).

6.1.5. Structural Design Calculations

The structural design calculation in general is under the responsibility of the designer, but the contractor should make sure that the tender documents include all necessary calculations. Also review these calculations and ensure they are correct, and no contradictions occur.

Also, in certain cases (ex: structural steel connections), the contractor should prepare all calculations and obtain the approval of the engineer, since they are related to the suppliers (materials and sections may vary) and designer can only provide a general guideline and minimum criteria.

6.1.6. Geotechnical and Site Investigation Reports

The Geotechnical report must include:

- Description of site and geology of the area.
- Seismicity factors in accordance with the location.
- All field exploration and In-situ tests.
- Ground water and cavities encounters.
- All laboratory tests including boreholes logs.
- All necessary conclusions and recommendations regarding foundation type and dept, allowable bearing capacity and settlements, excavations of side slopes or use of shoring, and backfilling materials.

6.1.7. Integrity of Structural Elements

6.1.7.1. Soil and Foundations

- Bearing capacity and foundation depth: It is important to follow all the instructions and recommendation stated in the geotechnical report regarding the desirable strata at which the foundation shall be laid. [5]
- Type of foundation: Also, all recommendation in the geotechnical report regarding the type of foundation (single footings, strip, or raft) should be followed, since (in addition to the loads on structure) it is related to the type of soil (sand, clay, marl, rock, etc). It is recommended not to use thickness of footing less than 250mm. [6]
- Ground water encounters: If groundwater was encountered in all the drilled boreholes, it should be pumped out using adequate trenches and sumps. Flotation shall be resisted solely by the reliable dead weight of structures neglecting all live loadings and backfill friction on foundation walls. Factor of safety of 1.25 against flotation shall be utilized in the design (minimum value unless indicated in the geotechnical report). [7]
- Tie and Ground Beams: Tie beams (at level of footings) and Ground beams (at level of S.O.G) are used to minimize the effects due to settlement of soils. [8]

- Foundation Insulation: Torch applied water proofing membrane with protection (cement screed) to be used under foundations, and for external surfaces of walls (exposed to soils). [9]

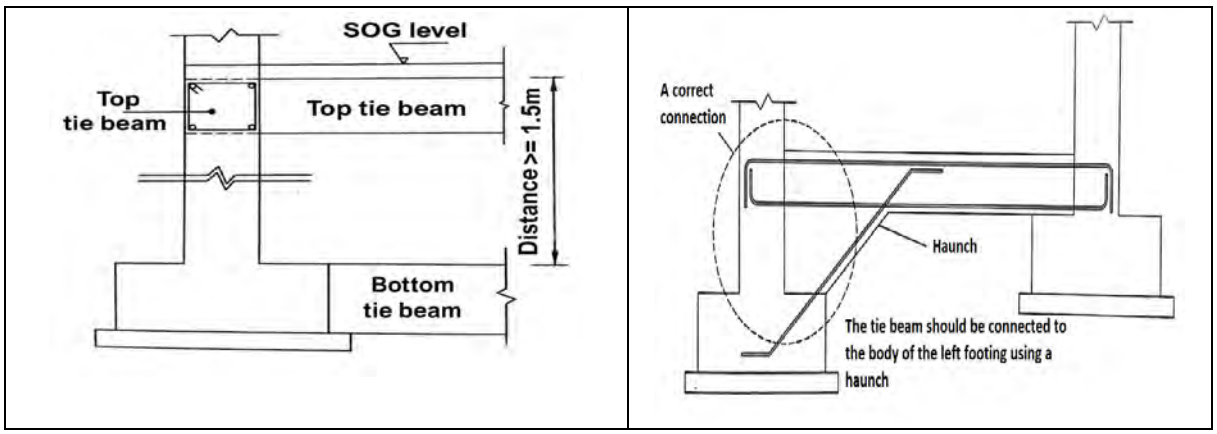


Figure 6-1: The Use of Tie and Ground Beams.

6.1.7.2. Integrity Against Siesmic Forces

6.1.7.2.1. Brief Discription

Dynamic actions are caused on buildings by earthquakes. In earthquake design of buildings, the building is subjected to a random motion of the ground at its base, which induces inertia forces in the building that in turn cause stresses that cause displacement-type loading on the building. [10] [11] [12]

The traditional earthquake-resistant design philosophy requires that normal buildings should be able to resist: (a) Minor (and frequent) shaking with no damage to structural and non-structural elements, (b) Moderate shaking with minor damage to structural elements, and some damage to non-structural elements, and (c) Severe (and infrequent) shaking with damage to structural elements, but with No collapse (to save life and properties).

6.1.7.2.2. Seismic Resisting Systems

Types of systems to resist horizontal seismic forces are limited, the three most common systems are:

- Shear walls
- Braced frames
- Moment frames

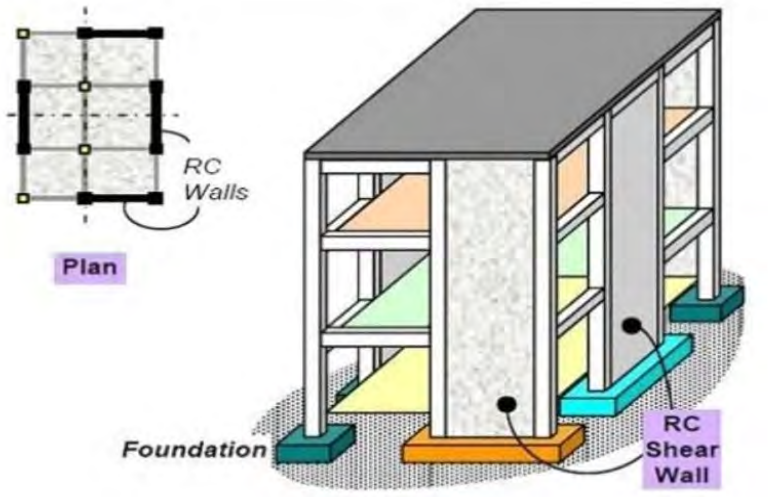


Figure 6-2: Shear Walls System

Figure 6-3: Braced Frames System

Figure 6-4: Moment Frames System

6.1.7.2.3. Seismic Factors

According to the selected resisting system above, and as per all the seismic factors that should be identified (will be described in the loading section), the modelling or structural design calculation of the building can be started to check certain values and limits.

6.1.7.2.4. Regular and Irrigular Configurations

Configuration is very much important for good seismic performance of the building. Configuration can be defined as: building size and shape, the size and location of structural elements. To makes the structure having good aesthetics and functionally effective, both shape and structural system must be sound enough. The wide range of the damages observed during past earthquakes across the world due to poor configuration. A building with simple geometry in plan has performed well during strong earthquake compared to complex and irregular shapes. When irregular shapes are included in a building, a higher level of engineering efforts is required to make the structure good earthquake resistant.

Accordingly, it is preferable to build a regular shape structures with symmetric geometry and enough resisting system. But this does not preclude (if required) the use of irregular shapes as long as the following issues and values are checked.

axial load, bending moment, her force, and torsion is reduced to remarkable extent by providing crumple section, which converts an irregular E-shape building into regular one.

6.1.7.2.5. Time Period

It is required to check the time period value (T) in both X and Y direction and compare it with the allowable time (Ta). If the value T > 1.4Ta, then it is checked. If the value T < 1.4Ta, then it is required to increase the number or sizes of the shear walls or the used bracing system.

6.1.7.2.6. Piers and Stories Forces

It is required to check that the piers (ex: Shear Walls) are taking more than 90% of the total produced base shear.

6.1.7.2.7. Center of Mass and Center of Regidity

It is required to check the difference between these two centres. If the difference is more than 20%, then beside the dynamic analysis check, the amplification factor (Ax) must be multiplied with the eccentricity in each floor and for each direction.

$$A_x = \left(\frac{\delta_{max}}{1.2\delta_{avg}} \right)^2$$

6.1.7.2.8. Structural And Architectural Drift Check

Types of movement for the building are: Displacement and Drift. Accordingly, the limit of each one has to be checked and compared with the allowable values in the adopted codes.

6.1.7.2.9. P-Δ Effect Check

It is required to check the effect of the vertical loads against the lateral stiffness of the structure and compare it with the allowable values to decide whether this check needs to be performed or not. [7]

$$\theta = \frac{P_x \Delta I_e}{V_x h_{sx} C_d}$$

(If ϑ < 0.1, then P- Δ effect is ignored)

6.1.7.3. Loads on Structures

Loadings generally must comply with the requirements of the local and / or international codes. All main loads will be listed below, bearing in mind that the designer may consider other loads (applied specifically on certain case) other than loads mentioned in this guideline. [10] [11]

6.1.7.3.1. Permanent Loads

Dead Loads

The dead load of structural components shall be estimated based on the material properties.

Superimposed Dead Load

The imposed dead loads are the weight of all materials and non-structural elements forming loads on the structure. Generally, consisting of the finishes of each floor and the ceiling loads which are supported by roof slab. For assessment of self-weight and superimposed dead load calculations, the following mass densities can be considered:

Table 2: Material Density.

Material	Density
Reinforced concrete	24.0 kN/m^3
Lightweight concrete	18.5 kN/m^3
Asphalt	22.0 kN/m^3
Structural steel	78.5 kN/m^3
Concrete Block	16.5 kN/m^3
Soil (Compacted)	22 .0 kN/m^3
Soil (uncompacted)	18 .0 kN/m^3
Ceramic Tile	0.80 kN/m^2

6.1.7.3.2. Live Load

Any moving load that is not caused by the weight of structural elements or superimposed load as mentioned above. For example, humans, equipment, mechanical or operational load, etc.

The nominal live loads should be taken as per the recommendation of the adopted codes. For the mechanical and operational load, refer to the mechanical and manufacturer drawings to assign the value and position of such load on the structure.

6.1.7.3.3. Temperature Load

Coefficient of thermal expansion of mature concrete (Alfa) =10 x10 E-6 /deg. C
The following temperature variations shall be considered above ground:

- Uniform Temperature rise: according to used codes.
- Uniform Temperature fall: according to used codes.

6.1.7.3.4. Earth Pressure Loads

Earth retaining structures shall be designed for lateral pressure caused by soil and / or load surcharges resting on retained soil. This load is obtained from the geotechnical report to determine all factors to calculate the lateral load. (Soil type, active soil pressure factor, angle of friction, etc). However, in cases where no sufficient data is provided, the following values are assumed and to be verified by the contractor:

- Soil density = 22.0 kN/m³. (Assumed unless otherwise is indicated in the geotechnical report).
- Internal friction angle $\emptyset = 30^o$ (Assumed unless otherwise indicated in the geotechnical report).
- $K_a = 0.333$ (Assumed unless otherwise indicated in the geotechnical report).
- $K_o = 0.5.$ (Assumed unless otherwise indicated in the geotechnical report).

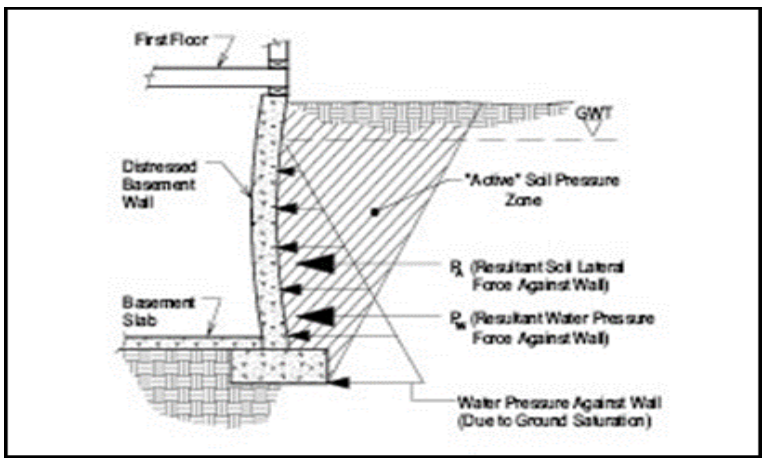


Figure 6-5: Earth Pressure Load

6.1.7.3.5. Liquid Pressure Loads

Liquid retaining structures shall be designed for both lateral and vertical pressure caused by the contained liquid (Water, sludge, etc.) So far, this load is called static liquid pressure in which the structure is subjected to pressure due to liquid unit weight only.

This load is related to the unit weight of the contained liquid and height of containing element (walls, base slab). Difference in unit weight (γ) should be considered in the design by knowing the function of the structure. The following table explains the used unit weights of several contained liquids, for more values, refer to the ACI 350 Code.

Table 3: Liquid Unit Weight.

Liquid	Density
Domestic water	10.0 kN / m^3
Raw sewage	10.0 kN / m^3
Grit from grit chamber	17.5 KN / m^3
Digested sludge aerobic	10.0 KN / m^3
Digested sludge anaerobic	11.0 KN / m^3

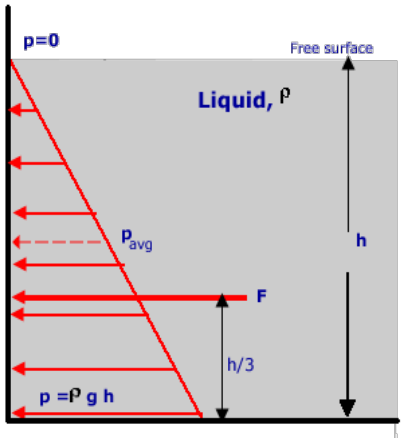


Figure 6-6: Liquid Pressure Load

6.1.7.3.6. Seismic Loads

Seismic load is determined according to Jordanian Seismic Code and the Uniform Building Code - UBC-97. Seismic variables will be based on the seismic zone and soil profile.

Seismic zone and all acceleration values will be chosen as per the Jordan Seismic Map, soil profile must be presented in the geotechnical report.

6.1.7.3.7. Wind Load

As per Jordanian design codes, design wind speed of (33m/s) is considered for the calculation of wind loads.

6.1.7.3.8. Loads Combinations

Combinations should cover the strength and stability of the structure, usability, and survival of structure under the worst events. Combinations should take into consideration all expected cases and may use more than reference regarding the applied load.

The following load combinations which are prescribed in the Jordanian Seismic Code (pp. 2-14) or equivalent from other codes will be considered in the detailed design:

- COMB1 = 1.4 (D + F)
- COMB2 = 1.4 (D + F + Ts) + 1.6 (L + H) + 0.5 (Lr or S or Ra)
- COMB3 = 1.2 D + 1.6 (Lr or S or Ra) + (f1 L or 0.8 W)
- COMB4 = 1.2 D + 1.6 W + f1 L + 0.5 (Lr or S or Ra)
- COMB5 = 1.2 D + 1.0 E + f1 L + f2 S
- COMB6 = 0.9 D + 1.6 W + 1.6 H
- COMB7 = 0.9 D + 1.0 E + 1.6 H

[13]

- D: Dead loads.
- E: Earthquake loads.
- F: Loads due to fluids.
- H: Lateral earth pressure.
- L: Live loads.
- Lr: Roof live loads.
- R: Rain loads.
- Ts: Self-straining force.
- W: Wind loads.

6.1.7.4. Reinforced Concrete Requirements

6.1.7.4.1. Aggregates

All course and fine aggregates shall have maximum size of 20mm for all concrete unless other specification is required. [14]

6.1.7.4.2. Concrete

Concrete Durability Requirements

- Minimum cement content – 350 kg/m^3 (unless otherwise is indicated in the geotechnical report).
- Maximum water-cement ratio – 0.45 (unless otherwise is indicated in the geotechnical report).
- Extended periods of moist curing.
- Use water reducing agents and (Pozzolans) to reduce permeability.
- 25mm minimum and 100mm maximum slump. [14]

Cement:

- For substructures, it is recommended to follow the instructions and recommendation of the geotechnical report regarding the type of cement, since it might be sulphate resistance cement (SRC).
- For other super-structure elements not in contact with soil or water, cement type is ordinary Portland cement unless otherwise recommended by the geotechnical report. [14]

Concrete Strength

Concrete shall generally conform to the requirements of (ACI 211,301,305 and 306). The minimum compressive characteristic cubic strength as defined by the standard 150 x 150mm concrete cube at 28 days (fcu):

Table 4: Minimum Concrete Strength (MPa)

Member Name	Concrete Strength (Cube) MPa
Foundations, Basement Walls, Shear Walls, Columns and Water Tanks	35
Slabs, Beams and Site Retaining Walls	30
Site Works, Slab on Grade (Excluding retaining walls or any tanks)	20
Plain Concrete	15

Concrete Cover

The nominal cover of concrete for all steel, including stirrups, links, sheathing, and spacers should be not less than 25mm for regular structures. However, a greater cover may be necessary at a face in contact with aggressive soils or water. According to ACI 350R-01 Code (Section 7.7), the concrete cover shall not be less than the values below: [14]

Table 5: Minimum Concrete Cover (mm)

Case	Concrete Cover (mm)
Concrete cast against and permanently exposed to earth	70
Concrete exposed to liquid, weather, or cast against a concrete work mat	50
Circular tanks with ring tension (walls)	50
Beams and columns (dry condition)	40
Beams and columns (exposed condition)	50
Formed footing surfaces and bottoms bearing on concrete work mat	50
Un formed footing surfaces and bottoms in contact with earth	70
Footings and base slabs over top of piles	50
Slabs in wastewater facilities.	40
Bottom face of slab on grade exposed to earth in all structures.	40
Other slabs	25

6.1.7.4.3. Reinforcement

All steel reinforcing bars used should possess a manufacturer's certificate indicating that the requirements given in Construction Standard with respect to the physical, chemical, and mechanical properties of the steel bars have been complied with.

All steel used in structural design shall be:

- High - tension steel reinforcement deformed bars Grade 60, yield stress (4200 kg /cm^2).

[15] [16] [17] [18]

6.1.7.5. Structural Steel Requirements

- All structural steel elements should confirm to ASTM A36.
- All steel bolts and threaded rods should confirm to ASTM f3125 - A325 with a minimum yield strength of 630 MPa.
- All anchor bolts and anchor rods shall conform to ASTM F1554, grade 105 with a minimum yield strength of 720 MPa.
- all welding electrodes should be (AWS A5.5) E70XX electrodes.
- Welding should be under controlled conditions and as approved by the engineer.
- All steel connections shall be designed by approved steel fabricator.
- steel members should be painted with total 2 coats 75-micron minimum thickness paint each layer with an approved primer coats as per specifications. surfaces of steel members should be cleaned thoroughly before painting as per project specifications.
- Non-shrink grout should be used to fill any gaps between steel and concrete elements. [19] [20] [21]

6.1.7.6. Special RC Elements Requirements

6.1.7.6.1. Main Elements Sizes

Slabs

Solid slab thickness is generally controlled by consideration of deflection and should be more than 125mm.

The initial thickness can be determined by the following equation:

Effective Depth = Effective Span/ratio

Also, it is recommended to refer to Table 9.5a in the ACI Code (shown below) to determine the first trial thickness of other types of slabs.

Table 6: Minimum Slab Thickness

TABLE 9.5(a)—MINIMUM THICKNESS OF NONPRESTRESSED BEAMS OR ONE-WAY SLABS UNLESS DEFLECTIONS ARE COMPUTED

	Minimum thickness, *h*			
	Simply supported	One end continuous	Both ends continuous	Cantilever
Member	Members not supporting or attached to partitions or other construction likely to be damaged by large deflections.			
Solid one-way slabs	$\ell/20$	$\ell/24$	$\ell/28$	$\ell/10$
Beams or ribbed one-way slabs	$\ell/16$	$\ell/18.5$	$\ell/21$	$\ell/8$

Beams

Minimum width of beams to resist 2 hours against fire is: 20 cm width for main beams, 12.5 cm width for secondary beams (Ribs), and it is recommended to choose the values from Table 9.5a (ACI Code) as the first estimate for the minimum depth of main and secondary beams and check it as per all the design requirements.

Also, as a first trial, the depth of beam can be taken as:

Beam Depth = Effective Span / (10 to 12).

Walls and Columns

It is recommended to verify the sizes of walls and columns as per the design outputs, but also as minimum values (as per the requirements of fire resistance), the following should be used:

- External Columns: 250mm.
- Internal Columns: 300mm.
- Shear Walls: 250mm.
- Basement Walls: 300mm.

[22] [23] [24]

6.1.7.6.2. Maximum Deflection

Maximum deflection due to loads shall not exceed the values below:

Table 7: Maximum Deflection

A	Beams	Deflection due to imposed loads
	Cantilevers	Length / 180
	Beams carrying plaster finish	Span / 360
	Roof beams not carrying plaster finish	Span / 200

	Purlins and sheeting rails	To Suit the characteristics of the sheeting
B	**Columns**	**Horizontal deflection**
	Each storey, top of column, brick, or plaster cladding	Height / 300
	Single storey portal framed structures, with metal cladding	Height / 90
C	**Crane girders**	**Deflection at point of maximum span moment**
	Vertical deflection due to static wheel loads	Span / 700
	Horizontal deflection (calculated on properties of top or bottom flange alone as applicable)	Span / 500

[22] [23]

6.1.7.6.3. Maximum Crack Width

In general, there are two types of cracks:

- Flexural cracks: Caused by main concrete direct tension and flexural (horizontal and vertical cracks) and prevented by proper main reinforcement.
- Thermal cracks: Caused by drying shrinkage and temperature effect on concrete (horizontal and vertical cracks) and prevented by proper distribution reinforcement.

Below are general notes to reduce cracking in concrete:

- It is preferable to use a large number of small diameter bars for main reinforcement rather than an equal area of larger bars.
- Maximum bar spacing should not exceed 300 mm.
- The crack width shall be limited to 0.2 mm for the exposed surface and for buried ones as per BS8007.

[25]

6.1.7.6.4. Control Joints

Expansion Joints

Expansion joints shall be provided due to different structural properties between parts, due to temperature, or to allow for differential settlement. Expansion joints shall be designed for the full range of movement anticipated due to creep, shrinkage, elastic shortening, and temperature effects. Distances between expansion joints shall not exceed 30m.

The expansion joint consists of the following materials (refer to the following figures):

- Sealant Mastics.
- Filling.
- Strip Sealants.
- Protective Capping.
- Water Stops.
- Joint Cover Strip.

Contraction Joints

Contraction joint purpose is to maintain contraction of concrete, it is a movement joint with deliberate discontinuity without initial gap between the concrete on either side of the joint. A contraction joint may be either complete contraction joint or partial contraction joint.

Construction Joints

This type of joint is provided for convenience in construction. The number of construction joints depends on the various factors such as availability of resources, time to be spent to complete a pour, the maximum possible supply of concrete, nature of the structure, etc. [25]

The following figures show the criteria of each type.

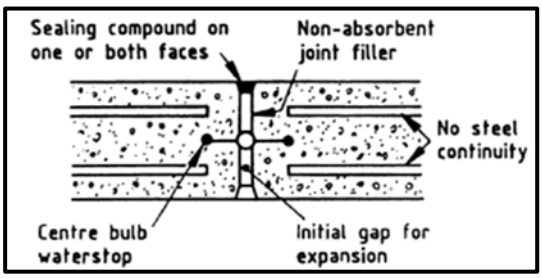


Figure 6-7: Expansion Joints in Walls

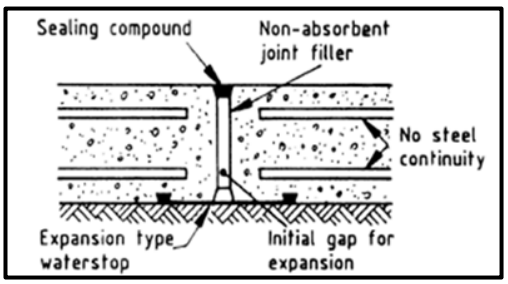


Figure 6-8: Expansion Joints in Floors

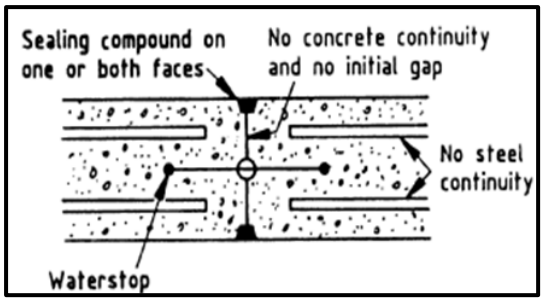


Figure 6-9: Complete Formed Contraction Joints in Walls

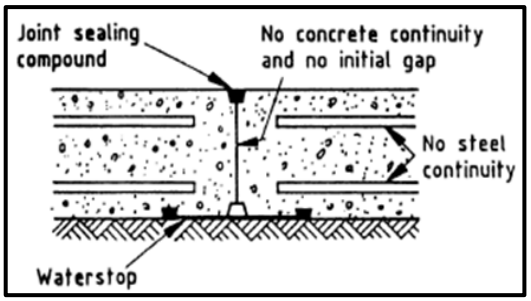


Figure 6-10: Complete Formed Contraction Joints in Floors

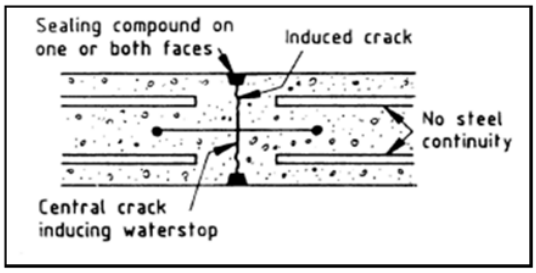


Figure 6-11: Complete Included Contraction Joints in Walls

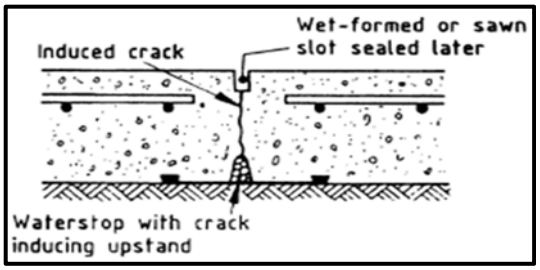


Figure 6-12: Complete Included Contraction Joints in Floors

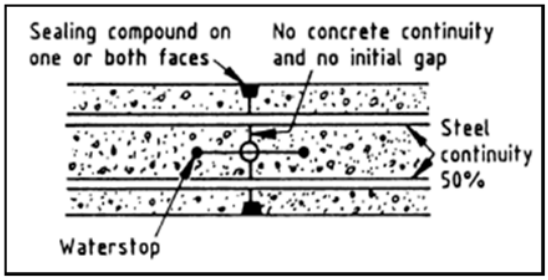


Figure 6-13: Partial Formed Contraction Joints in Walls

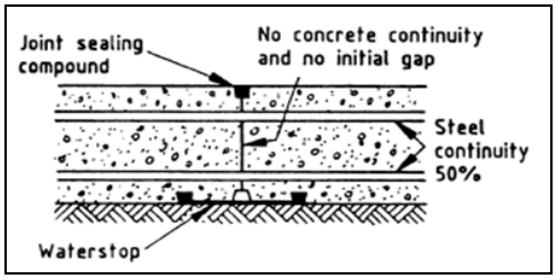


Figure 6-14: Partial Formed Contraction Joints in Floors

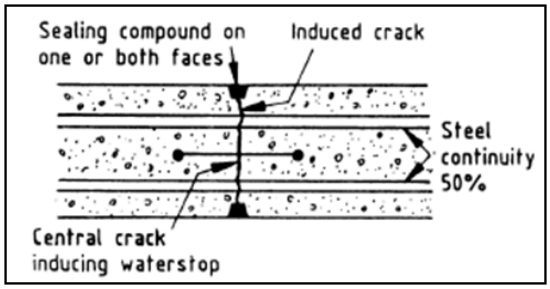


Figure 6-15: Partial Included Contraction Joints in Walls

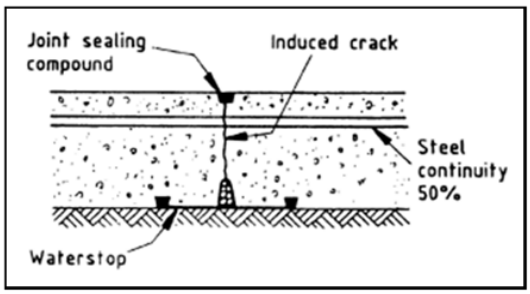


Figure 6-16: Partial Included Contraction Joints in Floors

6.1.7.6.5. Water Stop

Water stop must be used in between wall and foundation and areas of expansion and construction joints

6.1.7.7. Non - Structural Elements Requirements

- Add strengthening beams under slab on grade to strengthen it under block wall.
- Minimum thickness for the partition block walls should not be less than 70 mm.
- It is recommended to add lintels along the block walls if the wall height is greater than 3.0m (common floor height). [22]

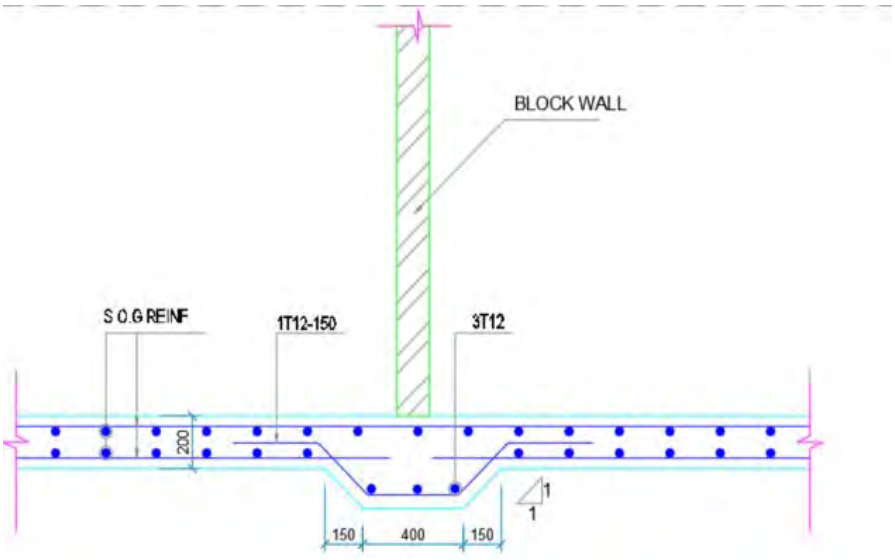


Figure 6-17: Ground Beam Under Partition Walls

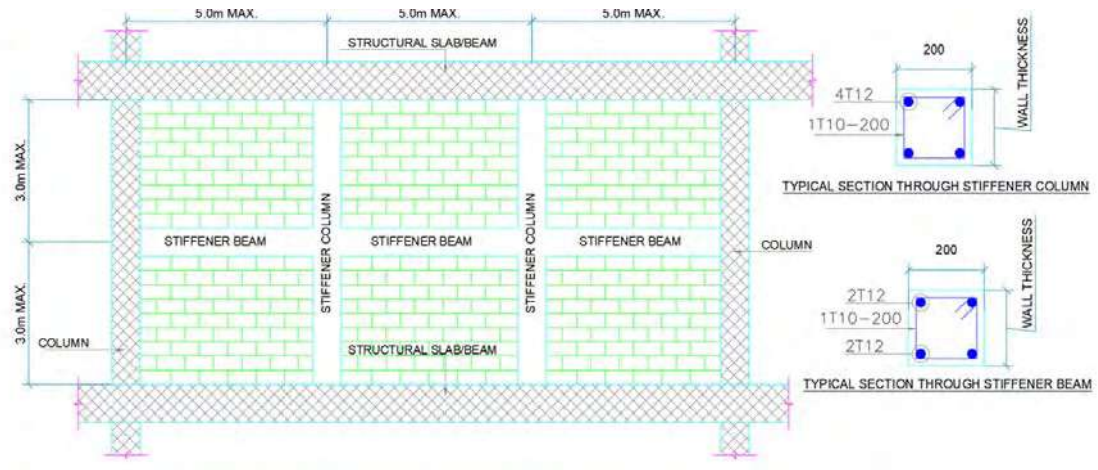


Figure 6-18: Stiffening of Partition Walls

6.2. Electrical Safety

6.2.1. Earthing System

While designing Earthing system for a new dormitory following points should be taken in consideration:

1. In Jordan Earthing system used is TN-S.
2. Overall Earthing Resistance should not exceed 1 ohm.
3. Main earthing bar is to be provided at point of service entrance or main distribution room. Connect all earthing conductors, protective conductors, and bonding conductors to the main earthing bar.
4. Earthing is highly related to soil resistivity value. [26] [27]

6.2.2. Lightning Protection System

Before designing lightning protection system for a new dormitory, following definition should be highlighted:

BS EN/IEC 62305 identifies four main sources of damage:

- S1 Flashes to the structure
- S2 Flashes near to the structure
- S3 Flashes to a service
- S4 Flashes near to a service

Each source of damage may result in one or more of three types of damage:

- D1 Injury of living beings due to step and touch voltages
- D2 Physical damage (fire, explosion, mechanical destruction, chemical release) due to lightning current effects including sparking
- D3 Failure of internal systems due to Lightning Electromagnetic Impulse (LEMP)

The following types of loss may result from damage due to lightning:

- L1 Loss of human life
- L2 Loss of service to the public
- L3 Loss of cultural heritage
- L4 Loss of economic value

BS EN/IEC 62305-2 specifically deals with making a risk assessment, the results of which define the level of Lightning Protection System (LPS) required.

Define class of lightning protection system (LPS) using any lightning risk management software, then you can define dormitory building required class of lightning protection system, accordingly using appropriate lightning protection method " rolling sphere method, mesh method , etc.." can protect your building . [28] [29]

6.2.3. Lighting System

6.2.3.1. Lux Requirements

While designing lighting system for anew dormitory, LUX level is an important figure, which should be achieved, below you can find major figures for LUX levels inside dormitory:

- Bedroom: general- 150 LUX.
- Corridor: general 100 LUX in daytime where there is no daylight input.

  After dark, but when people are still about, this can be reduced to 50 LUX.

  At sleeping time, when most people are asleep a minimum of 5 LUX is required condition that lighting control can restore the illuminance to 50 LUX.
- Kitchen "food preparation " : 500 Lux .
- Stairways within dwelling units and exterior stairways serving a dwelling unit shall have an illumination level on tread runs of not less than 1 footcandle (11 Lux).

  [30] [31]

6.2.3.2. Using Day Light

lighting design should maximize the use of natural daylight to provide illumination, minimizing electrical lighting loads and lighting consumption and, thereby, reducing internal heat gains.

Daylight strategy, therefore, has a strong effect on the requirement for mechanical ventilation and air conditioning. The additional capital cost of improving daylighting should be offset against the running cost savings in lighting, and the capital and running costs of mechanical ventilation or air conditioning to remove the heat it produces.

Effective control of the electric lighting is the key to realizing the potential energy saving from daylight. Electric Day light sensor should reduce light output when daylighting levels are adequate and when the space is unoccupied.

6.2.3.3. Lighting Design

Basics of Lighting System:

1. Optimum lighting design take into consideration the following:
   - Use as much as possible of natural daylight.
   - Avoid unreasonably high illuminance.
   - Contain the most efficient luminaires, control gear and lamps.
   - Involve effective lighting controls and occupancy sensor.

2. Selecting Luminaires:
    - A luminaire includes a housing, a reflector, a lamp and shielding.
    - The photometric efficiency is measured in terms of its light output ratio.
    - The factors affected in lamp selection are:
        - luminous efficacy (lumen output/watts input)
        - Wattage rating (consumption watts)
        - lumen maintenance (lumen depreciation over life)
        - Control gear type and controllability (switching or dimmable)
        - Colour rendering index CRI.
        - Colour temperature "in kelvin ".
3. Lighting Control: *Successful control of electric lighting is the key to achieving the potential energy saving from daylight.*
    - The control system for the electric lighting should reduce light output when daylighting levels are sufficient, and when the space is unoccupied.
    - The integration of daylight and electric lighting requires planning, the correct choice of light source and the correct controls to facilitate it.
    - Lighting controls should ensure that light is provided in the right amount, in the right place for the required time.
4. For best energy saving it is recommended to use occupancy sensor (presence detection). [32] [33]

6.2.3.4. Emergency Lighting (69)

Emergency lighting is required by local civil defence authority while designing new dormitory building. Emergency lighting can be of different types.

The emergency escape luminaires maybe stand-alone bulk lead units or integrated recessed, surface, pendant luminaires, or up-lights.

There are two basic types of luminaires: self-contained and slave.

6.2.3.4.1. Exit Illuminated Sign/Emergency Light: (69)

At points of emphasis, position a luminaire at or within 2m measured horizontally:

a. at each exit door intended for use in emergency
b. near stairs so that each flight of stairs receives direct light
c. at mandatory emergency exits and safety signs
d. at each change of direction
e. at each intersection of corridors
f. outside and near each final exit
g. near each first aid post

h. near each piece of firefighting equipment
i. near each alarm and call point
j. in lift cars

6.2.3.4.2. Escape Route: *(69)*

An escape route is a clearly defined, permanently unobstructed route with Minimum illuminance on the center line: 0.2 lx, but preferably 1 lx with Minimum duration: 1 hour.

6.2.3.4.3. Illuminated Signage:

- Color: conform to ISO 3864-1 chromaticity co-ordinates.
- Minimum luminance of safety color: 2 cd/m2.
- Luminance diversity: maximum/minimum luminance of color < 10.
- Luminance contrast range: luminance ratio of white to color > 5 but < 15.
- Maximum viewing distance (internally illuminated sign): 200 × mounting height.
- Minimum mounting height: 2 m above floor. [34]

6.2.3.4.4. Means of egress illumination

Means of egress illumination design for new dormitory should cover the following:

- Escape lighting should provide adequate visual conditions and directions for safe passage on escape routes and allow occupants to reach escape routes from open areas.
- It should allow fire alarm call points, fire lighting equipment and safety equipment to be identified.
- It should allow hazards (stairs, intersections, slopes) and hazardous processes to be identified and made safe during evacuation.
- The system shall be capable of powering the required load for a duration of not less than 180 minutes as per local civil defence code. [35]

6.2.4. Power System

Regarding safety issue while designing power system the following major points should be taken into consideration:

1. Protection against electric shock in normal service and in case of failure.
2. Ingress Protection (IP): An important consideration in the selection of electrical appliances.

Design of Electrical Installation:

1. The socket outlet that is according to BS 1363-2 or BS 1363-4 (British 13 A/230-240 V 50 Hz) grounded and fused.

2. The main distribution board (MDB) with metering to be of form (2b) and located in a dedicated electrical room. It will feed final consumer units (final distribution board) in each floor by vertical path for the cables between the main distribution board (MDB) and the final distribution board (DB).
3. Final socket-outlets circuits should be protected with MCB rated 16 A for each circuit, each circuit supplying a reasonable number of socket-outlets in series, taking into account the wiring cross-section area used (2.5 mm^2), the wiring lengths (voltage drops).
4. One dedicated circuit for each "high load" appliance such as washing machine, dishwasher, cooker etc. Water heater and fixed heater units shall be connected by dedicated fused spur outlet.
5. Number of socket outlet depends on the area, capacity, and function of the room itself.
6. Use waterproof in wet areas and Kitchen.
7. Duplex socket outlet must be near to TV outlet.
8. All A/C equipment, etc. shall be supplied with power outlets according to their specified loads. [36]

6.2.5. Solar photovoltaic (PV) power supply systems:

Solar photovoltaic PV system is a combination of interconnected PV cells that turn sunlight directly into electrical power, usually installed outside (usually at roof level); so, any external electrical work must be suitable for the environment and correctly IP rated to be chosen.

On grid system – combination from both PV and local electricity company – is usually used to cover the demand all day and night in addition to wintertime "cloudy days " [37]

6.2.6. Security Systems

6.2.6.1. Closed Circuit television (CCTV) System

A dedicated CCTV surveillance system shall be designed to monitor personal movement. For security purpose, with considerations to the privacy of inhabitants, cameras will be mainly located at the following points:

- Stairs and corridors
- All exits
- Main entrance
- Main hall, outdoor yards, and car parking.

A control room must be considered to house recorder element usually called "NVR or DVR ", screens/monitors and a security man, and connected to the administrator. [38]

6.2.6.2. Access Doors

Controlled access door system shall be used for special rooms, departments, etc...

6.2.6.3. Metallic Detector and Security Man

For valuable security level in dorms a metallic detector shall be used; this detector shall be used by the security man at the main entrance of the building. [39]

6.3. Fire safety

6.3.1. Fire Safety related to Architectural Configurations and Interior Design Applications

6.3.1.1. Site Requirements

6.3.1.1.1. Access Street/ Accessibility of Civil Defence Vehicles (61)

- Locate the building on a street or streets or on a clear empty space wide enough for a fire engine to access the site in case of emergencies.
- 9-meter-wide street is required for allowing emergency vehicular access [40]

6.3.1.1.2. Assembly points

- Assembly points are places designated outside the dormitory to assemble people who are evacuated. (Sizes of assembly areas are related to the building capacity)
- Assembly points must be connected to exits from the dormitories.
- They must be safe, secure, free of clutter, with natural ventilation, and must be accessible to cars and public service teams. [1]
- Borders/ location of Assembly areas should be identified with clear signage.

6.3.1.1.3. Buildings configuration

Each floor must have windows to transmit smoke and fire with an area of 2.5% of the total floor area excluding staircases, elevators, and toilets area. [41]

6.3.1.2. Means of egress

6.3.1.2.1. Evacuation and egress routes general requirement

- The number of means of egress from any story or portion thereof shall be as follows:
  1. Occupant load more than 500 but not more than 1000 –not less than 3
  2. Occupant load more than 1000 – not less than 4 [42]
- Provide at least two emergency exits for each floor.
- All exit doors must be always operational (for security reasons, doors can be locked with keys from outside, but doors are to be equipped with push bar handles that can unlock the door/override it in cases of emergency and to open outwards).

- Separation of means of egress and egress components needed:

  Vertical escape to ground level from upper floors is normally via open or protected stairways. When a stairway communicates more than two floors then they need to be separated from the adjacent areas with fire rated construction.

  Staircases should be protected with fire rated enclosures and doors at openings leading to these enclosures and shall also be provided with self-closing devices to ensure that doors close automatically after use.

  Escape stairs are to be protected all the way to discharges to outside at ground level.

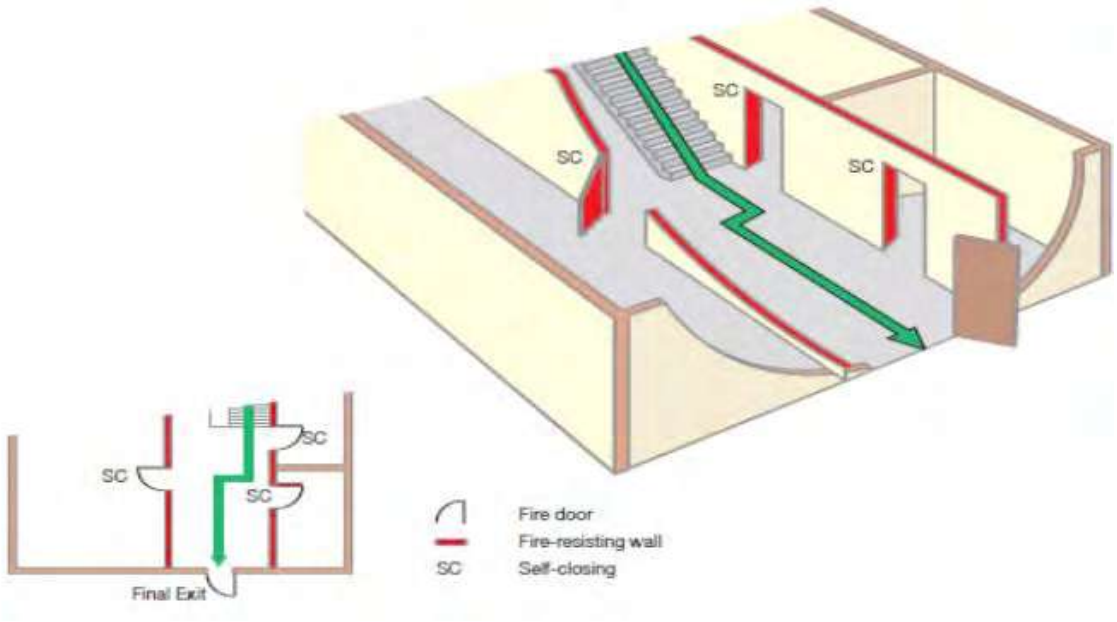


Figure 6-19: Protection of Staircases Enclosures

External escape staircases are also permitted if they lead directly to the ground, and are separated from the building interior by fire resistive assemblies or walls and are constructed of non-combustible materials.

External stairs need to be provided with a level of fire protection to prevent flames and smoke spreading via the façade of the building and affecting people using the stairs for escaping.

6.3.1.2.2. Exit access Corridors

- The minimum width for the exit passageway is 1.1m [31]
- The construction walls or partitions material is required to be 2-HR FRR [43]
- Fire-resistance-rated corridors shall be continuous from the point of entry to an exit and shall not be interrupted by intervening rooms, clutter or obstacles.
- When the path of egress within a fire-resistance-rated corridor to the exit includes travelling along unenclosed exit access stairways or ramps, the fire-resistance rating shall be continuous for the length of the stairway or ramp and for the length of the connecting corridor on the adjacent floor leading to the exit. [44]

6.3.1.2.3. Exit stairs

- 1-HR FRR is required when fire exit connects 3 or fewer stories [43]
- 2-HR FRR is required when fire exit connects 4 or more stories [43]
- The maximum clear height between stair flights is 3.7m [45]
- The minimum number of the steps in one stair flight are 3 steps and the maximum are 12 steps.
- The maximum height for the riser of the step is 18 cm and the minimum dimension for the tread is 28 cm
- The minimum stair width for the occupancy less than 50 person is 90cm and 110 cm for the occupancy equal or more than 50 persons.
- The railing should be provided at the open sides of external and internal egress stairs at the 860 mm above the FFL and should not exceed 960 mm and it is recommended to be consisting of vertical elements. [45]

6.3.1.2.4. Exit Doors

- Exit doors should be opened outwards with the same as egress direction.
- The minimum clear door opening width is 800mm and the maximum is 1200mm for a single leaf door.
- Headroom not less than 2.1m.
- 1-hr FR is required when fire exit connects 3 or fewer stories.
- 2-hr FR is required when fire exit connects 4 or more stories.
- Self-closing devices (Door Closer) for emergency doors are required.
- Fire Exit Doors shall be provided with panic device and should not be locked from inside. If locks are used, emergency egress shall be allowed using the panic device.
- The opening of the door shall not cause a reduction of the passageway to half of its actual width, it is preferable to use the door with opening angel 180 [46]

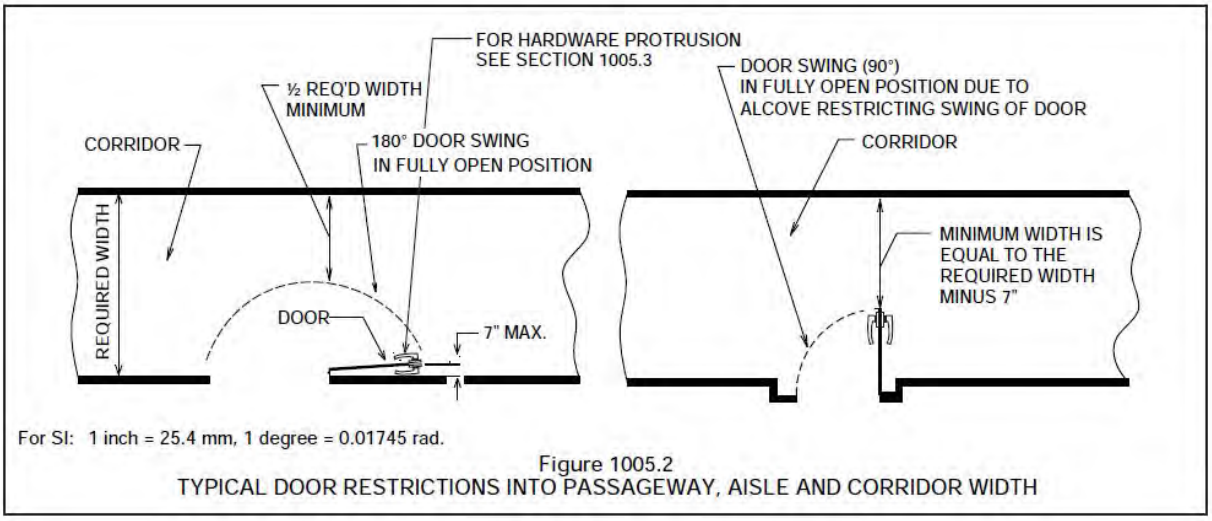


Figure 6-20: Restriction for Door Opening into a Corridor

6.3.1.2.5. Travel Distance and Dead end

The Dead End is the part of the corridor or egress path that do not lead to a door or an exit, or the escape option and reaching the exit from one direction only

- The maximum length for dead end corridors is 15m in buildings equipped with sprinklers and 10 m in buildings without sprinklers.
- The maximum travel distance to at least one exit shall not exceed 55 m in buildings not sprinklered or exceed 100 m in buildings protected throughout by an approved supervised sprinkler system. [47]

Table 4 : Travel Distance and Dead End

Building type	Max. Dead End (m)		Max. Egress Route (m)		Max. Common path	
	Without sprinklers	With sprinklers	Without sprinklers	With sprinklers	Without sprinklers	With sprinklers
Residential building (Dormitory building)	10	15	55	100	10	15

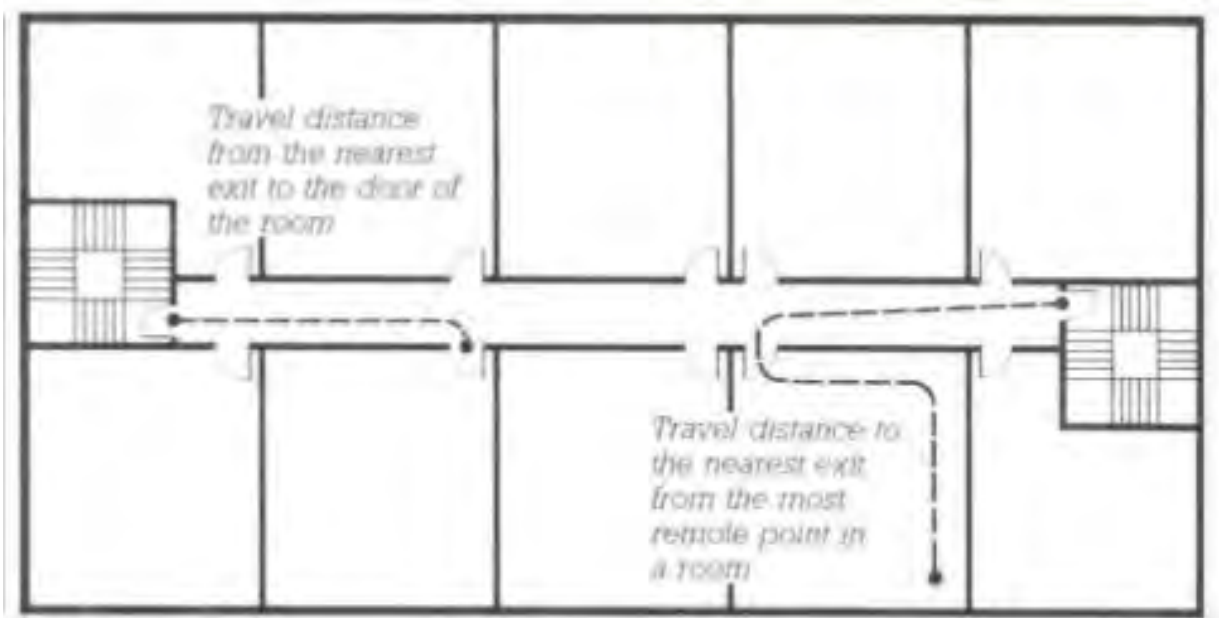


Figure 6-21:Travel Distance

6.3.1.3. Fire-rated enclosures for vertical shafts or storages: *(55)*

- Fire-rated doors and enclosures reduce the risk of fire spreading throughout a building. FR Doors should be sealed and properly fixed and fully operational wherever needed (All hardware sets and self-closing mechanisms are to be installed and in good working condition) .
- All fire rated doors are supposed to be stamped by the supplier to identify fire rating characteristics.

6.3.1.4. Signage *(19 ,56)*

- Each floor must have directional arrows and signs indicating escape routes.
- All exits and access ways should be marked by an approved sign readily visible from any direction of exit access.
- Any sign needed is to be provided in all languages of resident workers.
- Every sign should be so located and of such size, distinctive color, and design as to be readily visible and should provide contrast with decorations, interior finish, or other signs. It should be made of durable materials and fixed properly wherever needed, at min 1m high from F.F.L if wall mounted.

6.3.1.4.1. The name of dormitory signage *(19)*

The name of the dormitory should be indicated on a sign posted at the entrance of the dormitory. Such a sign is useful in reporting an emergency at the dormitory. [1]

6.3.1.4.2. Emergency/Evacuation map (56)

Provide each floor with an emergency map or plan at the entrance of each floor showing emergency exits and directions The plan must be clear and must show the actual layout of the building with exits, first aid boxes, water hoses, and fire extinguishers. [1]

6.3.1.5. Capacity of means of egress (01)

6.3.1.5.1. Occupant Load:

Total number of persons that occupies a building or part of a building together and in one period.

As per the Jordanian National Fire Protection Code its

10.00 M2/Person for dormitory buildings only.

Occupant Load (Number of persons) = Total Area / Occupant

6.3.1.5.2. Capacity factor:

Stair (mm per person) :8

Corridors and ramps(mm/person) :5

6.3.1.5.3. Load Factor

Number of persons x capacity factor = Exits capacity

[48]

6.3.1.6. Material

- The floor surface should be slip-resistant in aisles and corridors that serve as means of emergency egress.
- If you have one floor building then fire-resistant floors and walls should be not less than 30 minutes. If the total built up area is 3000 m^2, and if it is a multi-storey then fire resistance for building components should be as the following table. [49]

Table 5: Fire Resistance for Building Components with relevance to building size

Floor numbers	Floor Area (m^2)	Building height (m)	Fire resistance in hours for building components if it is part of	
			Ground level or upper floors	Basement's floor
Not more than 3 storeys	Unlimited	9.0	0.5	1.0
4 storeys	250	12.0	1.0	1.0
More than 4 storeys	3000	28.0	1.0	1.5
More than 4 storeys	2000	unlimited	1.5	2.0

6.3.1.6.1. Interior Finish in Exit Enclosures (49)

The Interior wall and ceiling finish materials are grouped in the following classes in accordance with their flame spread and smoke-developed indexes.

The Interior wall finish should be class A for fire exit closure and class A or B for lobbies and corridor. [50]

Table 6 : Interior finishes classes

	Class A	Class B	Class C
Flame Spread index	0-25	26-75	76-200
Smoke developed index	0-450	0-450	0-450

6.3.2. Fire Safety Related to Mechanical Systems

6.3.2.1. Firefighting System

6.3.2.1.1. Fire Hose Reels (62,63)

For Light Hazards:

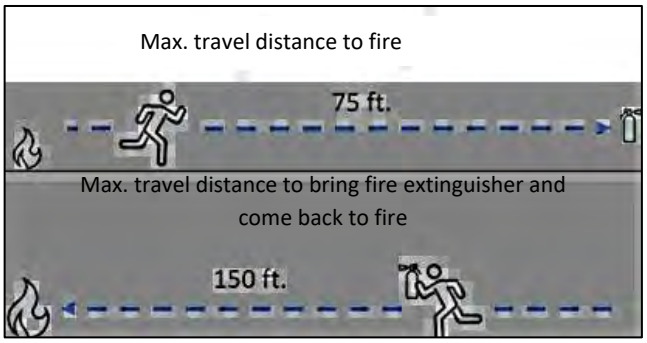
- One hose reel must be installed every 800m^2
- The flow rate must not be less than 60 l/min and the pressure must not be less than 3.0 bar. [51] [40]
- The maximum area covered by one hose shall be limited to the type of hazard as shown in the table below:

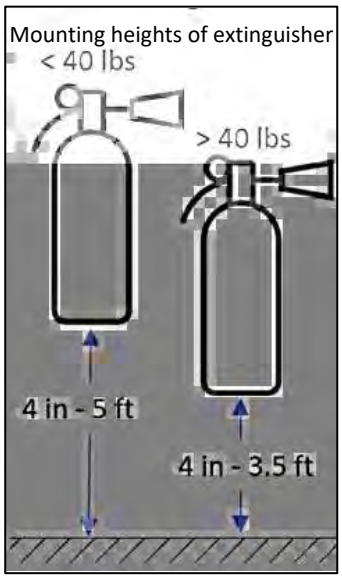
Table 71: Maximum Area covered vs. Type of Hazards

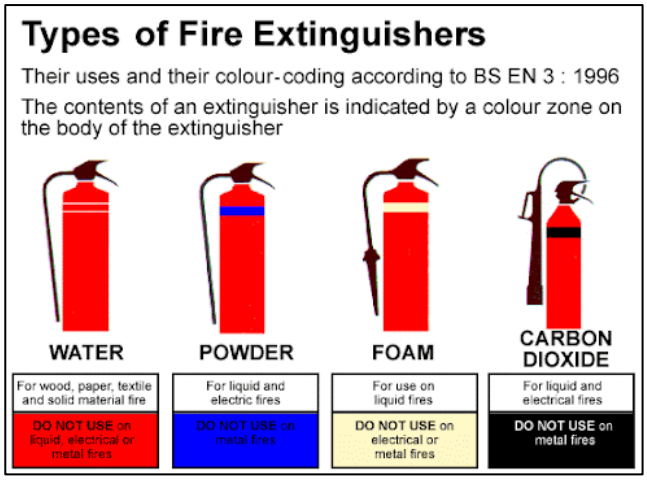
Type of hazard	Area (sq.m.)	Hose Diam. (mm)
Light	800	19 or 25
Ordinary	600	19 or 25
Extra	400	40

6.3.2.1.2. Portable fire extinguishers (64)

- Fire extinguishers shall be located along normal paths of travel, including exits.
- Portable fire extinguisher type, number and size is dependent on the type of potential fire with relevance to the room function and capacity. [40] [52]
- For Class A types (light Hazard), one fire extinguisher must be installed every 280m^2 with maximum travel distance to the fire extinguisher not to exceed 22m.
- Co2 fire extinguishers must be used in electrical rooms. While, ceiling hung powder extinguisher above the burner must be used in the boiler room.







Extinguisher Class	Max Travel Distance	NFPA 10 Section (2018 ed.)	Notes
Ordinary A Combustibles	75 ft	Table 6.2.1.1	Travel distance can be altered by the type of hazard anticipated and the numerical A rating of the extinguisher.
Flammable B Liquids	30 ft or 50 ft	Table 6.3.1.1	Travel distance is based on the type of hazard anticipated and the numerical B rating of the extinguisher. See table 6.3.1.1 below.
Electrical C Equipment	N/A	6.4.3	Since extinguishers are never only Class C rated you need to follow the Class A or Class B rating requirements.
Combustible D Metals	75 ft	6.5.2	
	30 ft	6.6.2	Class K: Cooking Media

- The minimal sizes of fire extinguishers for the listed grades of hazards shall be provided on the basis of the following table:

Table 12: Minimal Sizes Selection of Fire Extinguishers with relevance to Grade of Hazard

Criteria	Light Hazard Occupancy	Ordinary Hazard Occupancy	Extra Hazard Occupancy
Minimum rated single extinguisher	(2-A)	(2-A)	(4-A)
Maximum floor area per unit of A (m2)	280	140	90

6.3.2.1.3. Fire pump

Pumps must be selected based on the conditions under which they are to be installed and used.

For dormitories (light hazard), fire pumps must be selected to achieve a flow rate of 60 l/min and a residual pressure of 3.0 bar at the hose nozzle outlet, taking into consideration the pressure losses through the pipes and fittings. [40] [53]

6.3.2.1.4. Fire fighting water tank

The tank shall be sized so that the stored supply plus reliable automatic refill shall be sufficient to meet the demand placed upon it for the design duration.

For dormitories (light hazard) the design duration is 30 min. [54] [40]

6.3.2.2. LPG Safety (78)

6.3.2.2.1. Flexible Connectors

Flexible connectors length should not be more than 1.5m and the hose connectors length should not be more than 1.8m when installed inside the building and 4.5m when installed outside the building.

Flexible connectors should comply with the (ANSI Z21.24) standards.

Hose connectors should comply with the (UL 569) and (UL 21) standards. [55]

6.3.2.2.2. Emergency Shutoff Valve

An exterior shutoff valve to permit turning off the gas supply to each building in an emergency shall be provided the emergency shutoff valves shall be plainly marked as such and their locations posted as required by the authority having jurisdiction.

Emergency shutoff valves shall incorporate all the following means of closing:

- Automatic shutoff through thermal (fire) actuation [Were fusible elements are used, they shall have a melting point not exceeding 250°F (121°C).
- Manual shutoff from two or more remote locations.
- Manual shutoff at the installed location. [56] [57]

6.3.2.2.3. Cylinders Requirements

Liquefied Gas Cabinets and Cylinders Attachments' Requirements are as follows:

- Vapor Shutoff Valve
- Liquid Shutoff Valve
- Pressure Relief Valve
- Fixed Max. Liquid Level Gauge
- Overfilling Prevention Valve
- Double Backflow Check Valve

[56] [55]

6.3.2.2.4. Safety Distances in External Gas Cylinders

Table 13 : Safety distances in external gas cylinders

Amount of stored gas (KG) liquid.	Capacity of the used gas cylinders (KG) liquid.	Safety distance between the occupied building and the gas cylinder storage location (m)
<200	12.5	3
200-1000	50	5
1000-1500	50	10

6.3.2.2.5. Safety Distances inside buildings

Table 8 : Safety distance form gas cylinder storage inside buildings

Amount of stored gas (KG) liquid.	Capacity of the used gas cylinders (KG) liquid.	Safety distance between the occupied area and the gas cylinder storage location (m)
<200	12.5	3
200-1000	50	5
1000-1500	50	8

[55]

6.3.2.2.6. Storing Gas Room Outside Buildings

The following requirements shall be taken into consideration when storing the gas cylinders outside the building:

- The gas cylinder storage location must be at least 6m away from the building entrances and exits.
- The gas cylinder storage location must be surrounded by an iron fence with a height not less than the cylinder height to protect them from any outside danger.
- Gas cylinders must be protected from direct sunlight using sunshades made from materials that don't absorb heat and reflect sunlight.
- A 12Kg dry powder fire extinguisher must be installed in the Gas cylinder storage location. [55]

6.3.2.2.7. Storing Gas cylinders Inside Buildings

The following requirements shall be taken into consideration when storing the gas cylinders inside the building:

- The amount of stored gas in one location must not exceed 150 Kg liquid, and the amount stored on the same floor and in the same building may be increased if the distance between the two-storage location is not less than 100m
- The amount of stored gas must not exceed 1500 Kg liquid inside the building. *(81)*

. [55]

6.3.2.2.8. Connectors and Fittings

Installing connectors, fittings, and valves in accessible locations. [55] [56]

6.3.2.2.9. Gas Detectors

Using protective measures like gas detectors and flame detectors in the system, as well as using the proper firefighting system according to all related Jordanian Building codes and standards. [55] [56]

6.3.3. Electrical Fire Alarm and Detection Systems

6.3.3.1. Fire Alarm System

While designing a fire alarm system for a new dormitory building, the following points should be considered:

1. Installation places according to local civil defence code,
2. Smoke detectors at corridors, stairs, dining area,
3. Heat detectors at kitchens.
4. Fire Alarm Control Panel (FACP):

   It must be located within an accessible and visible place, and it is preferable to be at the entrance of the dorm, control room or near the civil defence entrance, or where there is 24-hour vigilance.
5. Manual call points:

   Must comply with (BS 5839: Part2), the time between operate the call point and the sound of the alarm must not exceed 3 seconds. It must be located at corridors and should exist in each floor and the crossing distance does not exceed more than 30m and mounting height installation at (1.1- 1.4) m above F.F.L.
6. Maximum distance between adjacent smoke detectors shall not exceed (5.1m) and the distance from the smoke detector to the farthest point in an area shall not exceed (7.5m).

7. Power Supplies: The power supply must be capable of handling the largest load when fire occurred. It must be connected to protective device and labelled by (DO NOT SWITCH OFF) and not RCCB. The continuity of power supply is important either from private generator or UPS device. And they must comply with: BS 5445:part7 or BS 5446:part 1 or BS 5839-5. Also local Jordanian civil defence code). [58] [59]

6.4. Public Health

6.4.1. Public Health related to Architectural Configuration and Interiors

6.4.1.1. Building Orientation *(71)*

- Locate the buildings to ensure adequate exposure to day light and nice views.
- Ensure adequate exposure to daylight and natural ventilation in existing occupied structures/rooms.
- Study windows and openings in building boundaries to ensure natural ventilation.

6.4.1.2. Ventilation *(75)*

- Buildings shall be provided with natural ventilation in accordance with Section 1202.5/IBC, or mechanical ventilation in accordance with the International Mechanical Code.
- Where the air infiltration rate in a dwelling unit is less than 5 air changes per hour where tested with a blower door at a pressure 0.2 inch W.C. (50 Pa) in accordance with Section R402.4.1.2 of the International Energy Conservation Code—Residential Provisions, the dwelling unit shall be ventilated by mechanical means in accordance with Section 403 of the International Mechanical Code. [60]

6.4.1.2.1. Opening Area required for Ventilation. (71)

The openable area of the openings to the outdoors shall be not less than 4 percent of the floor area being ventilated. [60]

6.4.1.2.2. Ventilation through Adjoining Spaces

Where rooms and spaces without openings to the outdoors are ventilated through an adjoining room, the opening to the adjoining room shall be unobstructed and shall have an area of not less than 8 percent of the floor area of the interior room or space, but not less than 25 square feet (2.3 m^2).

The openable area of the openings to the outdoors shall be based on the total floor area being ventilated. [60]

Exception: Exterior openings required for ventilation shall be allowed to open into a sunroom with thermal isolation or a patio cover provided that the openable area between the sunroom addition or patio cover and the interior room shall have an area of not less than 8 % of the floor area of the space, but not less than 20 square feet (1.86 m_2). The openable area of the openings to the outdoors shall be based on the total floor area being ventilated. [60]

6.4.1.3. Floor area per occupant (03)

Old density standards are weaker than that proposed in June 2020 (post-Covid standards). Before, standards called for 6.0 square metres per resident, net of shared facilities (which should be applied in existing buildings). The new standards call for 4.2 square metres per person excluding shared facilities (Which shall be used for new constructed dormitory buildings). [61]

6.4.1.4. Furniture (14)

- **Sleeping Beds**

✓ The height of the bed must not be less than 30 Cm from the floor and the beds must be separated from each other by not less than 70 Cm [1]

✓ Double deck bunks are not advisable for fire safety and hygiene reasons, and their use is minimised. Where they are used, there must be enough clear space between the lower and upper bunk of the bed. Standards range from to 0.7 to 1.10 metres. [2]

- **Shoe Racks**

✓ shoe racks in hallways on every floor that are sufficient for the number of workers in the dormitory to maintain hygiene and orderliness. [1]

✓ It is preferable to be recessed in the walls to ensure clear and no obstacles on exit corridor

✓ It is preferable to be with door to keep the corridor clean and in a good appearance

Figure 6-22 : Shoe Rack

- **Lockers**

Standards vary from providing an individual cupboard for each worker to providing 475-litre big lockers and 1 metre of shelf unit. [2]

- **Waste disposal** *(87 to 91)*

Trash collecting area should be identified and adequate distribution of trash bins should be provided. A waste basket of proper size should be available at each sanitary facility/toilet. Self-closing plastic containers are to be used. Each floor must have 1 container or more for solid waste (3liters/ worker). Trash should be emptied at least once a day.

[1]

- **Drinking fountain** *(18,73)*

Provide 1 drinking fountain per 150 workers [62]

ensuring good water quality provided.

The available water for consumption per person must not be less than 60 litres per day for personal consumption including drinking water.

6.4.1.5. Interior Partitions/ Separation walls (52)

Walls separating dwelling units in the same building, walls separating sleeping units in the same building and walls separating dwelling or sleeping units from other occupancies contiguous to them in the same building shall be constructed as fire partitions in accordance with Section 708/IBC. [63]

6.4.1.6. Building Envelope/ Doors and Windows (12)

Operable doors and windows are needed to ensure privacy and security measures are met, and to ensure they create no injuries if broken, or act as obstacles (if blocked) in case of emergency. They also prevent stray animals and insects from coming in.

6.4.2. Public Health related to Mechanical Systems *(92)*

6.4.2.1. Pluming system

6.4.2.1.1. Water Closets

Water closet bowls for public use shall be of the elongated type.
water closets shall be equipped with seats as required below:

- Water closet seats shall be of smooth, non-absorbent material.
- All water closet seats, except those within dwelling units, shall be either of the open front type or have an automatic seat cover dispenser.
- Water closet seats shall be properly sized for the water closet bowl type.
- Seats for use in public buildings shall conform to the ANSI Z124.5-97 standard.

[62]

6.4.2.1.2. Metered Faucets

Metered faucets shall be installed in public areas.
volume of the discharged water shall not exceed 1 Liter for each use. [64]

6.4.2.1.3. Minimum number of required fixtures

For dormitories, [62]:

Table 9 : Minimum number of required sanitary fixtures

Water closets (Fixtures per person)	Urinals (Fixture per person)	Lavatories (Fixtures per person)	Bathtubs or showers (Fixtures per person)	Drinking fountain (Fixtures per person)
Male: 1 per 10 Female: 1 per 8 Add 1 fixture for each additional 25 males (over 10) and 1 for each additional 20 females (over 8)	Male: 1 per 25 Over 150, add 1 fixture for each additional 50 males.	Male: 1 per 12 Female: 1 per 12 Over 12, add one fixture for each additional 20 males and 1 for each 15 additional females.	Male and female: 1 per 8 For females, add 1 bathtub per 30 over 150 add 1 bathtub per 20.	1 per 150

6.4.2.1.4. Cold and hot water networks

Each plumbing fixture shall be provided with an adequate supply of potable running water piped thereto in an approved manner, so arranged as to flush and keep it in a clean and sanitary condition without danger of backflow or cross-connection.

Water closets and urinals shall be flushed by means of an approved flush tank or flushometer valve.

Hot water must be provided for cleaning, bathing, and dishwashing purposes.

Hot water network should be designed so that all the fixture units are supplied with adequate flow and temperature.

Hot and cold-water networks must be supplied from the same source to control the mixing temperature and the flow rate at the mixer. [64] [62]

6.4.2.1.5. Heaters

All heaters and heat exchangers of all types shall be capable of heating the water to the desired temperature at the peak load. [64] [62]

6.4.2.1.6. Stored hot temperature

The stored hot water temperature must not exceed 65°c except for special cases, and when it is required to store the hot water at temperature higher than 65°c, proper materials must be used to counter the effects of the minerals that cause water-hardness.

6.4.2.1.7. Water temperatures

Limitation of hot water temperature for showers, bathtubs, basin, and kitchen sinks shall be 49°c

Limitation of hot water temperature for bidet shall be 43°c. [64]

6.4.2.1.8. Isolating valves

A full way valve controlling all outlets shall be installed on the discharge side of each water meter and on each unmetered water supply. Water piping supplying more than one building on anyone premises shall be equipped with a separate full way valve to each building, so arranged that the water supply can be turned on or off to any individual or separate building provided; however, that supply piping to a single-family residence and building accessory thereto may be controlled on one valve. Such shutoff valves shall be always accessible. A full way valve shall be installed on the discharge piping from water supply tanks at or near the tank. A full way valve shall be installed on the cold-water supply pipe to each water heater at or near the water heater. [62]

6.4.2.1.9. Sleeves

Proper sleeves shall be used when pipes are embedded inside walls or penetrating slabs. [62]

6.4.2.1.10. Energy consumption

To reduce the energy consumption, all hot water pipes must be thermally insulated.

To reduce the consumption of water, the return hot water network must be mounted at the most end of the supply hot water network. [64]

6.4.2.1.11. Rainwater

All roofs, paved areas, yards, courts, and courtyards shall be drained into a separate storm sewer system, or into a combined sewer system where a separate storm sewer system is not available, or to some other place of disposal satisfactory to the Authority Having Jurisdiction. In the case of one- and two-family dwellings, storm water may be discharged on flat areas such as streets or lawns so long as the storm water shall flow away from the building and away from adjoining property and shall not create a nuisance.

Storm water shall not be drained into sewers intended for sanitary drainage only. [62]

6.4.2.1.12. Size of drainage piping

The minimum sizes of vertical and/or horizontal drainage piping shall be determined from the total of all fixture units connected thereto, and additionally, in the case of vertical drainage pipes, in accordance with their length.

The below table shows the maximum number of fixture units allowed on any vertical or horizontal drainage pipe, building drain, or building sewer of a given size; the maximum number of fixture units allowed on any branch interval of a given size; and the maximum length (in feet and meters) of any vertical drainage pipe of a given size. [62]

Maximum Unit Loading and Maximum Length of Drainage and Vent Piping

Size of Pipe, inches (mm)	1-1/4 (32)	1-1/2 (40)	2 (50)	2-1/2 (65)	3 (80)	4 (100)	5 (125)	6 (150)	8 (200)	10 (250)	12 (300)
Maximum Units											
Drainage Piping[1]											
Vertical	1	2[2]	16[3]	32[3]	48[4]	256	600	1,380	3,600	5,600	8,400
Horizontal	1	1	8[3]	14[3]	35[4]	216[5]	428[5]	720[5]	2,640[5]	4,680[5]	8,200[5]
Maximum Length											
Drainage Piping											
Vertical, feet	45	65	85	148	212	300	390	510	750		
(m)	(14)	(20)	(26)	(45)	(65)	(91)	(119)	(155)	(228)		
Horizontal (unlimited)											
Vent Piping (See note)											
Horizontal and Vertical											
Maximum Units	1	8[3]	24	48	84	256	600	1,380	3,600		
Maximum Lengths, feet	45	60	120	180	212	300	390	510	750		
(m)	(14)	(18)	(37)	(55)	(65)	(91)	(119)	(155)	(228)		

[1] Excluding trap arm.
[2] Except sinks, urinals, and dishwashers.
[3] Except six-unit traps or water closets.
[4] Only four (4) water closets or six-unit traps allowed on any vertical pipe or stack; and not to exceed three (3) water closets or six-unit traps on any horizontal branch or drain.
[5] Based on one-fourth (1/4) inch per foot (20.9 mm/m) slope. For one-eighth (1/8) inch per foot (10.4 mm/m) slope, multiply horizontal fixture units by a factor of 0.8.

6.4.2.1.13. Wastewater treatment

wastewater must be discharged from the dormitories1 in one of

the following methods:

Connecting it to the public sewerage system, if available, with the approval of the competent authority.

Draining it to a concrete septic tank with proper specifications, emptying it before it becomes full and disposing of it at places designated by the competent authority. [62]

6.4.2.1.14. Cleanouts

Each cleanout fitting and each cleanout plug, or cap shall be of an approved type.

Each horizontal drainage pipe shall be provided with a clean out at its upper terminal, and each run of piping, that is more than one hundred (100) feet (30,480 mm) in total developed

length, shall be provided with a clean out for each one hundred (100) feet (30,480 mm), or fraction thereof, in length of such piping.

An additional cleanout shall be provided in a drainage line for each aggregate horizontal change of direction exceeding one hundred and thirty-five (135) degrees (2.36 rad). [62]

6.4.2.1.15. Vent Pipes

Each plumbing fixture trap shall be protected against siphonage and back-pressure, and air circulation shall be ensured throughout all parts of the drainage system by means of vent pipes installed. [62]

6.4.2.1.16. Vent termination

Each vent pipe or stack shall extend through its flashing and shall terminate vertically not less than six (6) inches (152 mm) above the roof nor less than one (1) foot (305 mm) from any vertical surface. [62]

Each vent shall terminate not less than ten (10) feet (3048 mm) from, or at least three (3) feet (914 mm) above, any openable window, door, opening, air intake, or vent shaft, nor less than three (3) feet (914 mm) in every direction from any lot line, alley and street excepted.
Vent pipes shall be extended separately or combined, of full required size, not less than six (6) inches (152 mm) above the roof or fire wall.
Flag poling of vents shall be prohibited except where the roof is used for purposes other than weather protection. All vents within ten (10) feet (3048 mm) of any part of the roof that is used for such other purposes shall extend not less than seven (7) feet (2,134 mm) above such roof and shall be securely stayed.

Vent pipes for outdoor installations shall extend at least ten (10) feet (3,048 mm) above the surrounding ground and shall be securely supported.

Joints at the roof around vent pipes shall be made watertight by the use of approved flashings or flashing material. [62]

6.4.2.2. Building envelops and AC System

6.4.2.2.1. Thermal comfort

The following are thermal comfort measures:

- Operative Temperature: For given values of humidity, air speed, metabolic rate, and clothing insulation, a comfort zone may be determined.
- Humidity Limits: Systems designed to control humidity shall be able to maintain a humidity ratio at or below 0.012, which corresponds to a water vapor pressure of 1.910 kPa (0.277 psi) at standard pressure or a dew-point temperature of 16.8°C (62.2°F).
- Elevated Air Speed: elevated air speed to be used to increase the maximum temperature for acceptability if the affected occupants are able to control the air speed.

- Local Thermal Discomfort: The local thermal discomfort caused by a vertical air temperature difference between the feet and the head by an asymmetric radiant field, by local convective cooling (draft), or by contact with a hot or cold floor must be considered in determining conditions for acceptable thermal comfort.
- Temperature Variations with Time: Fluctuations in the air temperature and/or mean radiant temperature may affect the thermal comfort of occupants. Those fluctuations under the direct control of the individual occupant do not have a negative impact on thermal comfort, Fluctuations that occur due to factors not under the direct control of the individual occupant (e.g., cycling from thermostatic control) may have a negative effect on comfort, Fluctuations that occupants experience as a result of moving between locations with different environmental conditions are allowed as long as the conditions at all of these locations are within the comfort zone for these moving occupants. [65]

6.4.2.2.2. Thermal Transmittance

The table below shows the maximum required U-value for walls ($W/m^2.K$):

External walls	0.57
Internal walls	2.0

[66]

The table below shows the maximum required U-value for roof and floors ($W/m^2.K$):

Roof	0.55
Internal floors	1.2
Floor above outside area	0.8

[66]

6.4.2.2.3. Thermal Insulation

Thermal insulation should be implemented in all floors, roofs, external walls, and internal walls as per the U-values in the table above to reduce the energy consumption used for heating or cooling the building. [66]

6.4.2.2.4. Indoor air temperatures

For residential building the indoor design temperature range should be as follows:

21°C to 19°C during the winter.

21°C to 23°C during the summer. [66]

6.4.2.2.5. Temperature and Relative Humidity Values Air-Conditioned spaces

Occupied space relative humidity shall be designed to be limited to 65% or less.

for thermal comfort purposes, temperature could range from between approximately 67 and 82 °F (19 and 27) °C. [65]

6.4.2.3. Ventilation system

6.4.2.3.1. Ventilation Requirements

Ventilation is the process of changing the air inside a closed space where the air resulting from breathing, bacteria, body odors, smoke, fumes, or dust is exhausted from the closed space and replaced with fresh air, ventilation must be done for any reason listed below:

- Prevention of concentration of unwanted odor, dust, or bacteria.
- Extraction of burning products and heat generated from bodies or mechanical and electrical equipment.
- Constantly changing air to prevent the accumulation of Oxo-carbons and increase the percentage of Oxygen.
- Ensure air movement. [67]

6.4.2.3.2. Minimum amount of outside air

The minimum amount of outside air for dormitories in breathing zones is shown in the table below:

Table 10 : Minimum amount of outside air

Occupancy Category	People Outdoor Air Rate (L/s. person)	Area Outdoor Air Rate (L/s. m^2)	Air Class
Bedroom/living Room	2.5	0.3	1
Barracks sleeping areas	2.5	0.3	1
Laundry rooms, central	2.5	0.6	2
Laundry rooms within dwelling units	2.5	0.6	1
Lobbies/ Pre-function	3.8	0.3	1
Multi-purpose assembly	2.5	0.3	1

Air class 1: Air with low contaminant concentration, low sensory-irritation intensity, and inoffensive odor, recirculation, or transfer of Class 1 air to any space shall be permitted.

Air class 2: Air with moderate contaminant concentration, mild sensory-irritation intensity, or mildly offensive odors. Class 2 air also includes air that is not necessarily harmful or objectionable but that is inappropriate for transfer or recirculation to spaces used for different purposes, recirculation of Class 2 air within the space of origin shall be permitted, Transfer of Class 2 air to toilet rooms shall be permitted, Class 2 air shall not be recirculated or transferred to Class 1 spaces. [68]

6.4.2.3.3. Ventilation Methods

Ventilation can be done by using one or both of the following methods:

1. Natural Ventilation through windows and doors

2. Mechanical Ventilation through one of the following methods:

- Extract system: A system that consists of one exhaust fan or more to extract air from closed spaces, ducts may be used in this system to extract air through walls and roofs.
- Input system: which is a system that is similar to the extract system except that the air is compressed into the closed space.
- Combined extract and input system: which is a system that combines the two systems mentioned above. [67]

6.4.2.3.4. Ventilation and Air-Conditioning Equipment

Installing Heating, Ventilation and Air-Conditioning Equipment: This equipment must be installed in easily accessible locations, with sufficient manoeuvring spaces for maintenance works according to the values stated in detail in this section.

Otherwise, the manufacturer's instructions and recommendations are applied.

6.4.2.3.5. Air-Filters

Air filter selection depends on many factors, such as the air purity level required, size of dust specks, the air pressure drop when the filter is clean and when it needs cleaning, the running cost, and the maintenance cost. [67]

6.4.2.3.6. Noise Level

The table below shows the acceptable DB levels in dormitories:

Table 17: Acceptable DB levels in dormitories

	Low DB level	Normal DB level	High DB level
Dormitories	33	40	48

[67]

6.4.2.4. Central Heating system

6.4.2.4.1. Fuel Tank's

Fuel Tank's capacity shall last 21 days of consumption at peak load. Also, fuel tanks shall be provided with a fuel level indicator.

External Fuel Tanks are installed in one of the following ways:

- Above ground level with or without concrete protection from erosion and weathering.
- Above ground level with protection using firewalls.
- Buried directly below ground level.

- Below ground level inside a brick or concrete wall room.

Fuel tanks inside buildings shall be placed in a fire-resistant room and as close as possible to the boiler room, also a fuel pipe shall run from the fuel room to an appropriate filling point

location, in compliance with the fire-prevention codes and standards from the Jordanian Building Codes.

Fuel tank's room shall be provided with proper air ventilation, as air inside the room shall be changed at least six times per hour, in compliance with the fire-prevention codes and

standards from the Jordanian Building Codes.

Fuel collection pit shall be provided below the fuel tanks with a capacity equal to the capacity of the biggest fuel tank inside the room plus 10%. [69] [70]

6.4.2.4.2. Ventilating Boiler Rooms Naturally

Naturally ventilated boiler rooms shall be connected through openings to ambient air, the used opening's area shall not be less than 5% of the room's area. [69] [70]

6.4.2.4.3. Ventilating Boiler Rooms Mechanically

In case of inability to ventilate the boiler room naturally, a mechanical ventilation system shall be provided and is capable of changing the air inside the room at least six times per hour.

[69] [70]

6.4.2.4.4. Boilers

All boilers shall be provided with a thermostat, relief valve, temperature gauge, pressure gauge, and draining valve.

The boiler's heating unit shall be provided with automatic control and safety devices.

Low water level cut-out shall be provided, and that is achieved using an electrical float valve installed in the expansion tank or using an electrical valve for breaking pressure installed directly on the boiler.

Boilers with heating capacity exceeding 1200 KW shall be provided with monitoring devices on the chimney connection to measure the percentage of CO_2 in the exhaust and to regulate the intake of clean air, also the boilers' burners shall be of automatically calibrated type according to water temperatures in the system and exhaust temperatures.

Adding shunt protection pump is a must for boilers with a capacity of 600 KW or above.

6.4.2.4.5. Heating Exchangers

Temperature gauges shall be installed on the supply and return pipes to and from the heat exchanger.

Each heat exchanger shall be provided with a Safety Valve. [69] [70]

6.4.2.4.6. Expansion Tanks

Open expansion tanks shall be installed at least 1.22 meters higher than the highest point of the heating system, and each tank shall be connected to a water supply pipe installed at the tank's midpoint, with an overflow pipe with at least 25 mm diameter positioned at the top of the tank. [69] [70]

6.4.2.4.7. Chimneys

Boiler's combustion exhaust shall be discharged to ambient air using vertical chimneys designed appropriately according to the boiler and fuel types.

Chimneys that serve only one boiler shall have at least the same cross-sectional area of the boiler-chimney connector.

Neglected chimneys' openings shall be tightly sealed.

The chimney's height shall be at least 950 mm higher than the highest point of the building including the parapet and the staircase. Also, it must be taken into consideration that the chimneys height reduces as much as possible hazards resulting from exhaust gases produced from nearby buildings, trees, or others.

Vertical chimneys shall be insulated according to the material used for manufacturing the chimney, when the chimneys interior surface is constructed using firebricks, with 50 mm gap of stagnant air surrounding the chimney from all directions, it is sufficient to insulate the chimney using wraps of Rockwool with thickness no less than 25 mm. In case the gap between the chimneys concrete shaft and the metal vertical part of the chimney is larger than 50 mm, the chimney must be insulated using wraps of Aluminium-Coated Rockwool with thickness no less than 50 mm. [69] [70]

6.4.2.4.8. Valves

The Isolating Valves shall be easy to use and maintain periodically, they are usually used for: main pipes, secondary pipes, exposed devices - like sectional radiators, panel radiators, and finned radiators – and secondary polyethylene pipes, and one of their most suitable types is Gate Valve.

Regulating Valves shall be installed on secondary pipes and devices connected to it, like sectional radiators, panel, radiators, finned radiators, and others, and that is to achieve the hot water flowrate required in the design. [69] [70]

6.4.2.4.9. Pipes

Water feeding pipe shall be coated in places exposed to freezing effects or in warm places where condensation occur on the pipe's external surface. [69] [70]

6.4.2.4.10. Hot water pipes Insulation

All hot water pipes and storage tanks shall be thermally insulated with thermal materials that have a thermal resistance more than or equal $R \geq 1.25\ m^2$.k/w. [69] [70]

6.4.2.5. Acoustic Environment

6.4.2.5.1. Airborne sound

Walls, partitions and floor-ceiling assemblies separating dwelling units and sleeping units from each other or from public or service areas shall have a sound transmission class of not less than 50, or not less than 45 if field tested, for airborne noise where tested in accordance with ASTM E90.

Alternatively, the sound transmission class of walls, partitions and floor-ceiling assemblies shall be established by engineering analysis based on a comparison of walls, partitions and floor-ceiling assemblies having sound transmission class ratings as determined by the test procedures set forth in ASTM E90. [71]

6.4.2.5.2. Masonry

The sound transmission class of concrete masonry and clay masonry assemblies shall be calculated in accordance with TMS 0302 or determined through testing in accordance with ASTM E90. [71]

6.4.2.5.3. Structure-borne sound.

Floor-ceiling assemblies between *dwelling units* and *sleeping units* or between a *dwelling unit* or *sleeping unit* and a public or service area within the structure shall have an impact insulation class rating of not less than 50, or not less than 45 if field tested, where tested in accordance with ASTM E492. Alternatively, the impact insulation class of floor-ceiling assemblies shall be established by engineering analysis based on a comparison of floor-ceiling assemblies having impact insulation class ratings as determined by the test procedures in ASTM E492. [71]

7. Spaces Data sheets and layout

a. Sleeping Room

Sleeping Room			
Size	21 m^2 (for bunk beds) / 42 m^2 (For single)		
# of Workers	**6**		
m^2 Per Worker	3.5 m^2 for bunk beds / 7 m^2 For Single		
Room Finish Schedule			
Windows	MIN.1 m^2	Double glazed	
Door	1.1m x 2.2m Structural opening		
Ceiling	Min. 2800mm height	Plaster and Paint	
Walls		Plaster with washable semi-gloss paint	
Floor and Base		Porcelain Ceramic Tile: Semi Polished / non-Porous	
Furniture /Equipment /Services			
QTY	**Fixed Furniture**	**QTY**	**Services**
1	Room number Sign	**-**	Ceiling lighting per layout
1	Mirror	**7**	Electric power duplex outlets
QTY	**Movable Furniture**	**-**	Heating radiators in cold areas
6	Sleeping Bed (90x200cm) Or		
3	Bunks beds	**QTY**	**Equipment**
3	curtain or partitions between beds for privacy	6	Reading Lamp
1	Window blind		
6	1 meter of shelf unit or 475 liter big locker		
1	Small Table (70cm x 90cm)		
3	chair		

[1] [2]

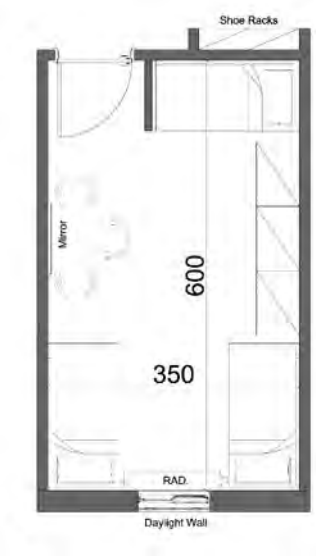


Figure 7-1:Sleeping Room -Single Bed-NTS

Figure 7-2 :Sleeping Room-Bunk Bed -NTS

- In collective rooms, which are minimised, in order to provide workers with some privacy, only a reasonable number of workers are allowed to share the same room. Standards range from 2 to 8 workers. [2]
- Double deck bunks are not advisable for fire safety and hygiene reasons, and their use is minimized. Where they are used, there must be enough clear space between the lower and upper bunk of the bed. Standards range from to 0.7 to 1.10 metres. [2]
- Triple deck bunks are prohibited. [2]

b. Sleeping Room for Disabled people

One sleeping Room at least for disabled people should be available at ground floor level along with a HC toilet beside it.

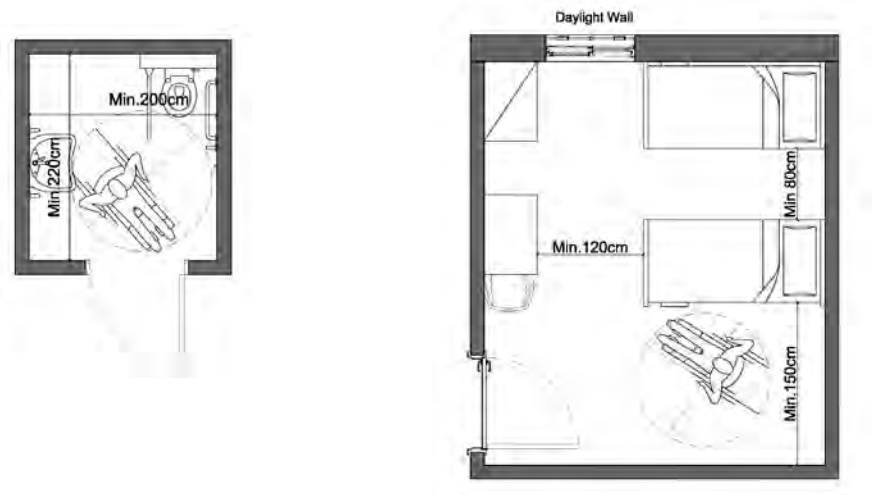


Figure 7-3: Sleeping Room and toilet layout for disabled people-NTS [72]

c. **Sanitary Facilities** (including toilets, washbasins, showers and changing rooms)

Toilets, Showers and changing Room			
Size			
Number of Stalls toilet	Refer to table 15** in the previous section		
Number of Showers	Refer to table 15		
Number of changing rooms	1 per 15 workers		
Room Finish Schedule			
Windows		Double glazed	
Door			
Ceiling	2800mm height *	Plaster and Paint	
Walls	extend to 2100mm	Ceramic Tile	
Floor and Base	Slope to drain	Porcelain Ceramic Tile: Semi Polished / non-Porous	
Furniture /Equipment /Services			
QTY	**Fixed Furniture**	**QTY**	**Services**
1	Room Sign		Ceiling lighting per layout
1	Mirror		Electric power duplex outlets
	Coat Hanger (3 per changing room)		Heating radiators in cold areas
			Hot and cold-water sinks
QTY	**Movable Furniture**	**QTY**	**Utilities**
-	Waste Basket (1 Per toilet)	-	Worker toilet
3	Large Waste Basket		
QTY	**Equipment**	-	Sink or if it is a common sink with a number of taps, each tap considered a separate sink
-	Toilet Paper Holder (1 per toilet)		Floor drain at each shower
3	Paper Towel Dispenser		
	Soap Dispenser (1 per 2 Faucets)		
-	Shower soap dispenser (1 per shower)		

*The minimum ceiling height at sanitary facilities is 2.1m [73]

[62] [1] [2]

- Shower compartments shall be finished with a smooth, nonabsorbent surface to a height not less than 72 inches (1829 mm) above the drain inlet.

  **Standards range from 1 unit per 15 persons (pre-COVID) to 1 unit per 6 (post-COVID). [2]

  **Note: it is recommended to provide 1 toilet, bathroom and 1 sink to every 5 beds (post-COVID), as an improvement from every 15 beds implemented before (pre-COVID), this development was suggested by Singapore government. [74]

d. Kitchen / Cooking Area

Kitchen / Cooking Area			
Size			
m^2 Per Worker	0.45 m2		
Room Finish Schedule			
Windows		Double glazed	
Door			
Ceiling	*2800mm height	Plaster and Paint	
Walls		Ceramic Tile	
Floor and Base	Slope to drain	Porcelain Ceramic Tile: Semi Polished / non-Porous	
Furniture /Equipment /Services			
QTY	**Fixed Furniture**	**QTY**	**Services**
1	Room Sign		Ceiling lighting per layout
	Base and upper Cabinets with 90cm counter height		Electric power duplex outlets
QTY	**Movable Furniture**		Heating radiators in cold areas
-	Waste Basket		Hot and cold-water sinks
QTY	**Equipment**	**QTY**	**Utilities**
-	Cooker / Oven	-	Sink and drainer
-	microwaves	-	Floor drain
-	Refrigerator		Washbasin for cleaning
-	Coffee maker		
-	Refrigerator		
-	Coffee maker		

[1] [2] [75] [76]

- * Kitchens, storage rooms and laundry rooms shall have a ceiling height of not less than 7 feet (2134mm) above the finished floor. [77]
    - Kitchens shall have a clear passageway of not less than 3 feet (914 mm) between counter fronts and appliances or counter fronts and walls. [78]
    - Kitchen Walls shall be ceramic tiles that are not less than 2 meters high.
    - Wherever located in dormitories, domestic cooking appliances for use by residents shall be in compliance with all of the following:
        1. The types of domestic cooking appliances shall be limited to ovens, cooktops, ranges, warmers, coffee makers and microwaves, limited to approved locations.
        2. Cooktops and ranges shall be protected in accordance with Section 904.13.
        3. Cooktops and ranges shall be provided with a domestic cooking hood installed and constructed in accordance with Section 505 of the International Mechanical Code. [79]
    - Pest and rodent control devices shall be provided.

e. Dining Hall / Canteen

Dining Hall / Canteen			
Size			
m^2 Per Worker	1.5 m^2		
Room Finish Schedule			
Windows		Double glazed	
Door	Provide Escape door on the opposite side of the main entrance or on the side where a large number of workers are present [1]		
Ceiling	Min.2800mm height	Plaster and Paint	
Walls		Plaster with washable semi-gloss paint	
Floor and Base		Porcelain Ceramic Tile: Semi Polished	
Furniture /Equipment /Services			
QTY	**Fixed Furniture**	**QTY**	**Services**
1	Room Sign		
QTY	**Movable Furniture**	**QTY**	**Utilities**
-	Dining Tables	-	Ceiling lighting per layout
	Chairs		Electric power duplex outlets
	Benches		Wall mounted fan with safety cover
QTY	**Equipment**	-	Heating radiators in cold areas
	Drinking fountain		AC this area per mechanical layout
			WIFI

[1] [2]

- The door of any sanitary facility must not open directly onto the kitchen or the dining room and the distance between the door of the sanitary facility and the kitchen or dining room door must not be less than 4 m.

f. Laundry Facilities

Laundry Facilities			
Size			
m^2 Per Worker	1.5 m^2		
Room Finish Schedule			
Windows			
Door			
Ceiling	*2800mm height	Plaster and Paint	
Walls		Plaster with washable semi-gloss paint	
Floor and Base		Porcelain Ceramic Tile: Semi Polished / non-porous	
Furniture /Equipment /Services			
QTY	**Fixed Furniture**	**QTY**	**Services**
1	Room Sign		
QTY	**Movable Furniture**	**QTY**	**Utilities**
	Cabinets		
QTY	**Equipment**		
	Hanging Lines 1m per worker / outside		
	Washing Machine		
	Dryer		

[1] [2]

- * Kitchens, storage rooms and laundry rooms shall have a ceiling height of not less than 7 feet (2134mm) above the finished floor. [77]

- Laundry areas are to be located away from the sleeping quarters and the kitchen.
- Provide separate places outside of the dormitories for hanging clothes after washing with an average of 1 meter of clothesline per worker. [1]
- If washing machines and dryers are provided, it must ascertained that all washing machines, dryers, and electric are safely connected.
- Chemical substances that are used for cleaning, such as acids and other cleaning materials, must be stored safely to avoid burns, especially to the eye. These materials must be stored in a self-closing plastic container for waste collection.
- The washing and drying area must not be slippery.

g. First Aid

First Aid			
Size			
Room Finish Schedule			
Windows			
Door		With vision panel	
Ceiling	Min.2800mm height	Plaster and Paint	
Walls		Plaster with washable semi-gloss paint	
Floor and Base		Porcelain Ceramic Tile: Semi Polished	
Furniture /Equipment /Services			
QTY	**Fixed Furniture**	**1**	Soap dispenser
1	Room Sign		
1	Coat Hanger	**QTY**	**Services**
QTY	**Movable Furniture**	**-**	Ceiling lighting per layout
1	Visitor chair	**2**	Electric power duplex outlet
1	Desk with files and chair	**-**	Heating radiator in cold areas
1	Cot (75x200cm) at 60 cm high	**-**	AC per mechanical layout
QTY	**Equipment**	**1**	Hot and cold-water sink
1	Refrigerator		Data outlet for computer / phone per elec.

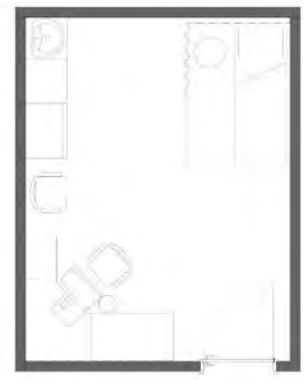


Figure 7-4: First Aid Room - NTS

h. Recreational facilities

The minimum amount of Gross Floor Area (GFA) for the recreational amenities is dependent on the number of workers/residents within the dormitory. Refer to the table below for requirements . [4]

NO. of workers/Residents housed in a dormitory	Minimum GFA dedicated for Indoor Recreational Amenities	Minimum Land Area dedicated for Outdoor Recreational Facilities
50 to 300	50 m^2	100 m^2
301 to 500	75 m^2	150 m^2
501 to 999	100 m^2	250 m^2
1000 to 5000	0.10 per worker	0.30 m^2 per worker (Minimum of one 240sqm hard court) And 0.15 m^2 per worker of open grass field (over and above outdoor recreational space and green buffer/planting strip requirements) with at least 1 field of minimum 100sqm Only recreational spaces shall be counted towards this provision requirement

Examples of indoor recreational facilities are multi-purpose rooms, gymnasium, reading rooms, TV rooms, and basketball courts. A reasonably size TV room or a gymnasium is 24 and 40sqm respectively.

Other facilities like outdoor games courts, recreation and socializing areas are strongly encouraged to be provided within the development. [4]

Enhancing the Structural Integrity of Dormitory Buildings in Jordan's Garment Sector- Phase II

Annex A

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List of References

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