

# AutoCAD Fundamentals

## Class 13: Building Codes & Bye-Laws

👤 Prepared by: Er. Ajay Bhattarai

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### Understanding Building Codes

💡 **What is a Building Code?** A building code is a comprehensive collection of regulations and standards that establish the minimum requirements for the design, construction, and maintenance of buildings.

#### 💡 Purpose:

- **Safety:** Protection of occupants from structural failure, fire, and hazards
- **Structural Integrity:** Buildings can withstand environmental loads (wind, earthquake, snow)
- **Health:** Proper ventilation, sanitation, and hygiene standards
- **Sustainability:** Energy efficiency and environmental considerations
- **Accessibility:** Universal design principles for all users

💡 **Nepal Building Code (NBC):** The National Building Code of Nepal provides standardized guidelines for construction across the country, with particular emphasis on seismic safety due to Nepal's location in a high-risk earthquake zone.

⚠️ **Important:** Compliance with building codes is not optional—it's a legal requirement. Non-compliance can result in construction halts, demolition orders, fines, and legal liability in case of structural failure.

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### Nepal Building Code (NBC) Categories

#### ☰ NBC 000-100 Series: Material & Load Standards

- **NBC 000:** International State-of-the-Art practices and references
- **NBC 101:** Material Specifications (concrete, steel, masonry standards)
- **NBC 102:** Unit Weight of Materials (density values for calculations)
- **NBC 103:** Occupancy Load / Imposed Load (live load requirements)
- **NBC 104:** Wind Load (pressure calculations for different zones)

### NBC 000-100 Series (Contd.)

- **NBC 105:** Seismic Design of Buildings in Nepal (*Updated 2020*)
- **NBC 106:** Snow Load (particularly for high-altitude regions)
- **NBC 107:** Provisional Recommendations on Fire Safety
- **NBC 108:** Site Consideration for Seismic Hazards

### NBC 109-114: Structural Material Standards

- **NBC 109:** Masonry: Unreinforced (load-bearing walls, partitions)
- **NBC 110:** Plain and Reinforced Concrete (RCC design standards)
- **NBC 111:** Steel (structural steel design and connections)
- **NBC 112:** Timber (wooden structural members and joints)
- **NBC 113:** Aluminium (lightweight structural applications)
- **NBC 114:** Construction Safety (site safety protocols)

### NBC 200 Series: Mandatory Rule of Thumb (MRT)

- **NBC 201:** MRT for RCC Buildings with Masonry Infill
- **NBC 202:** MRT for Load Bearing Masonry structures
- **NBC 203:** Earthquake Resistant Construction - Low Strength Masonry (*Updated 2015*)
- **NBC 204:** Earthquake Resistant Construction - Earthen Buildings (*Updated 2015*)
- **NBC 205:** MRT for RCC Buildings Without Masonry Infill (*Updated 2024*)
- **NBC 206:** Architectural Design Requirements (*Updated 2024*)
- **NBC 207:** Electrical Design Requirements for Public Buildings
- **NBC 208:** Sanitary and Plumbing Design Requirements

 **Pro Tip:** Always check for the latest updates! NBC 205 and NBC 206 were recently updated in 2024. Using outdated codes can lead to design rejections during approval processes.

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Building Bye-Laws: Local Regulations

 **What are Building Bye-Laws?** Building bye-laws are legal regulations established by local authorities (municipalities, municipal corporations) to govern planning, design, construction, and use of buildings.

 **Key Areas Controlled:**

- **Planning:** Land use, zoning, plot requirements

- **Design:** Building height, coverage, setbacks, FAR
- **Construction:** Material standards, construction methods
- **Use:** Occupancy types, change of use regulations

### Scope of Bye-Laws:

- Ensure safe, orderly, and sustainable urban development
- Maintain adequate open spaces, ventilation, and natural light
- Regulate building density and infrastructure load
- Protect environmental and community interests
- Enable future urban expansion and infrastructure upgrades

 **Key Difference:** While NBC provides technical standards, bye-laws control spatial and urban planning aspects specific to each locality.

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## Ground Coverage Ratio (GCR)

 **Definition:** Ground Coverage Ratio (GCR) is the percentage of the plot area that can be covered by the building's footprint at ground level.

### Formula:

$$\text{GCR (\%)} = \left( \frac{\text{Ground Floor Built-up Area}}{\text{Total Plot Area}} \right) \times 100$$

### Significance of GCR:

- **Ventilation & Light:** Ensures adequate open spaces for natural airflow and sunlight
- **Green Spaces:** Maintains balance between constructed and unconstructed areas
- **Drainage:** Provides permeable ground area for rainwater absorption
- **Fire Safety:** Open spaces act as fire breaks between buildings
- **Density Control:** Regulates building density to prevent overcrowding
- **Aesthetic Quality:** Maintains visual openness and prevents claustrophobic environments

### Practical Example:

**Given:** Plot Area = 500 m<sup>2</sup>, Allowed GCR = 50%

**Calculation:**

$$\text{Maximum Ground Coverage} = 500 \times \frac{50}{100} = 250 \text{ m}^2$$

**This means:**

- Maximum ground floor area = 250 m<sup>2</sup>
- Minimum open area required = 250 m<sup>2</sup> (50%)
- Upper floors can extend to full GCR limit (if structurally supported)

## 📍 Typical GCR Values in Nepal:

- **Core Urban Areas:** 40-50% (higher density zones)
- **Residential Zones:** 50-60%
- **Suburban Areas:** 60-70% (lower density)
- **Rural/Agricultural:** 70-80% (minimal restrictions)

❗ **Common Mistake:** GCR applies only to ground-level coverage. Upper floors may cantilever or project beyond ground floor footprint (within setback limits), but the ground footprint must not exceed GCR.

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## Floor Area Ratio (FAR)

❖ **Definition:** Floor Area Ratio (FAR) is the ratio of the total floor area of all floors in a building to the total plot area. It determines the extent of vertical construction allowed on a plot.

### ▣ Formula:

$$\text{FAR} = \frac{\text{Total Built-up Area of All Floors}}{\text{Total Plot Area}}$$

### ☒ Significance of FAR:

- **Vertical Growth Control:** Regulates building height and total construction volume
- **Population Density:** Manages the number of occupants per unit area
- **Infrastructure Planning:** Ensures roads, utilities, and services can support population load
- **Land Use Efficiency:** Promotes optimal utilization of urban land
- **Urban Character:** Maintains skyline and neighborhood character
- **Economic Impact:** Higher FAR increases land value and development potential

### ⚖️ Types of FAR:

- **Permissible FAR:** Maximum FAR defined by local authorities
- **Achieved FAR:** The actual FAR implemented (must be Permissible FAR)
- **Base FAR:** Standard FAR for a zone
- **Premium FAR:** Additional FAR granted upon payment of development charges
- **TDR:** Transfer of Development Rights - unused FAR that can be transferred

### ▣ Practical Example:

**Given:** Plot Area = 1,000 m<sup>2</sup>, Allowed FAR = 2.0

## Calculations and Configurations:

### Calculation:

$$\text{Maximum Total Built-up Area} = 1,000 \times 2 = 2,000 \text{ m}^2$$

### Possible configurations:

- 2 floors  $\times$  1,000 m<sup>2</sup> each = 2,000 m<sup>2</sup>
- 4 floors  $\times$  500 m<sup>2</sup> each = 2,000 m<sup>2</sup>
- 5 floors  $\times$  400 m<sup>2</sup> each = 2,000 m<sup>2</sup>

## Typical FAR Values in Nepal:

- **Core Commercial Areas:** 2.5-4.0 (high-density zones)
- **Mixed-Use Zones:** 2.0-3.0
- **Residential Areas:** 1.5-2.5
- **Suburban Zones:** 1.0-1.5
- **Heritage/Conservation Areas:** 0.5-1.0 (restricted development)

**⚠ Important:** FAR calculations typically exclude basement parking, mechanical rooms, lift shafts, and sometimes open terraces and balconies. Always verify exclusions with local authority regulations!

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## Plot Area & Its Components

**॥ Definition:** Plot area refers to the total horizontal land area within the legal boundaries of a property, typically measured in square meters (m<sup>2</sup>) or square feet (sq.ft).

### Components of Plot Area:

1. **Built-up Area:** Area covered by building footprint (ground floor coverage)
2. **Open Area:** Uncovered portions - courtyards, gardens, pathways, parking
3. **Setback Area:** Mandatory buffer zones around the building
  - Front setback (from road)
  - Rear setback (from back boundary)
  - Side setbacks (from side boundaries)
  - Cannot be built upon (except specific exceptions like porches)

### Significance:

- **Foundation for Calculations:** Base value for FAR, GCR, and other parameters
- **Legal Boundary:** Defines property limits and ownership extent

## Significance (Contd.):

- **Development Rights:** Determines maximum permissible construction
- **Valuation Basis:** Used for property taxation and market value assessment
- **Zoning Classification:** Minimum plot sizes apply for different land uses

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Key Differences: GCR vs FAR

Aspect	GCR	FAR
<b>Focus</b>	Horizontal coverage	Vertical construction
<b>Formula</b>	$(\text{Ground area} \div \text{Plot}) \times 100$	Total built-up ÷ Plot
<b>Purpose</b>	Limits footprint for open spaces	Regulates total volume
<b>Unit</b>	Percentage (%)	Ratio (unitless)
<b>Applies To</b>	Ground floor only	All floors combined
<b>Controls</b>	Building footprint	Total construction volume

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Essential Bye-Law Terminologies

- **1. Right of Way (ROW)** Legal right to use a strip of land for transportation or utilities. Ensures unobstructed movement and protects areas from encroachment.
- **2. Building Envelope** The outermost boundary of a building including walls, roof, and floors. Defines maximum extent of built structure.
- **3. Super Built-up Area** Built-up area including proportional share of common areas like staircases, corridors, lobbies. Typically 10-25% more than carpet area.
- **4. Mezzanine Floor** Intermediate floor between two main floors, covering partial area. Often used for storage or offices.
- **5. Easement** Legal right to use part of another property for specific purposes (access, utilities). Does not transfer ownership.
- **6. Plinth Area** Covered area at ground floor level including external walls. Used for construction costs and tax assessments.
- **7. Service Lane** Narrow passage for service access, waste collection, maintenance. Typically 3-6 meters wide.
- **8. Built-to-Line** Designated line for building's front wall construction. Ensures uniform street alignment.
- **9. Open Terrace** Uncovered flat area on roof. Often used for recreation or utilities. May be excluded from FAR.
- **10. High-Rise Building** Building exceeding local height limits. Requires special safety measures. Often defined as 15-20m or 5+ floors.
- **11. Parking Space** Designated vehicle storage area. Standard:  $2.5m \times 5m$  per car. Requirements vary by building use.

 **12. Encroachment** Illegal occupation beyond allowed boundaries. Subject to demolition and penalties.

 **13. Hazard Line** Line demarcating areas prone to natural hazards. Construction restricted or prohibited beyond this line.

 **14. Minimum Plot Size** Smallest permissible plot size for construction. Prevents subdivision into unviable parcels.

 **15. Floor Height** Vertical distance between finished floor and ceiling. Standard: Residential 2.7-3.0m, Commercial 3.0-3.6m.

 **16. Green Belt** Area reserved for vegetation and parks where construction is restricted. Often required as 15-20% of plot.

 **17. Mixed-Use Zone** Zone allowing multiple functions (residential, commercial, recreational) in same area.

 **18. Occupancy Certificate** Document certifying building complies with regulations and is safe for occupancy. Required for utilities.

 **19. Structural Safety Certificate** Certificate confirming structural stability and seismic compliance. Required for occupancy certificate.

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## Essential Drawing Types for Building Approval

### Architectural Drawings

- **Floor Plan:** Horizontal section showing room layouts, dimensions, doors, windows
- **Roof Plan:** Top view showing roof layout, slopes, drainage
- **Elevations:** Vertical views of all building faces showing external appearance
- **Sections:** Vertical cut-through views showing internal height relationships
- **Location Map:** Context map showing building location within neighborhood
- **Site Plan:** Plot boundary, building footprint, setbacks, access, parking
- **Opening Schedule:** Detailed table of all doors and windows with specifications

### Structural Drawings

- **Foundation Layout Plan:** Location and type of all foundations
- **Column Layout Plan:** Position, size, and grid reference of all columns
- **Footing and Foundation Details:** Design, reinforcement, dimensions
- **Beam Details:** Size, reinforcement, and connection details
- **Column Details:** Reinforcement schedule, bar bending details
- **Slab Details:** Thickness, reinforcement layout, distribution bars
- **Staircase Details:** Structural design including reinforcement
- **Detailing of Structural Members:** Bar bending schedules, connections

**?** **Pro Tip:** Both architectural and structural drawings must be coordinated and match in dimensions. Any discrepancy can lead to construction issues and approval delays. Always cross-check before submission!

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## Most Used Symbols in AutoCAD

### ⌨ Essential Symbols with Shortcuts

lightgray Symbol	Code	Usage
Diameter ( $\emptyset$ )	<code>%%C</code>	Denoting diameter of circles, pipes, holes
Degree ( $^\circ$ )	<code>%%D</code>	Angular dimensions, slopes, rotations
Plus/Minus ( $\pm$ )	<code>%%P</code>	Tolerance in dimensions and variations
Square Meter ()	<code>\U+33A1</code>	Area measurements in plans
Rebar ()	<code>\U+2300</code>	Reinforcement bars in structural drawings
Delta ()	<code>\U+0394</code>	Changes in elevation/level

### ℹ How to Use Special Characters:

#### Method 1: Using %% Codes

- Type code directly during MTEXT or DTEXT
- Example: `%%C25mm` displays as  $\emptyset 25\text{mm}$
- Example: `45%%D` displays as  $45^\circ$

#### Method 2: Using Unicode

- In MTEXT editor: Right-click → Symbol → Other
- Type `\U+` followed by the code

### ★ Practical Examples:

- **Columns:** `300mm %%C RCC Column` →  $300\text{mm } \emptyset \text{ RCC Column}$
- **Slopes:** `Roof Slope 15%%D` → Roof Slope  $15^\circ$
- **Tolerances:** `Level %%P5mm` → Level  $\pm 5\text{mm}$
- **Area:** `Floor Area: 150\U+33A1` → Floor Area: 150
- **Reinforcement:** `12\U+2300 @ 150mm c/c` → 12 @ 150mm c/c
- **Center Line:** `CL %%v` → CL with vertical line (Center Line symbol)
- **Square Symbol:** `200\U+25A1` → 200 (used for section dimensions)
- **Angle Symbol:** `45\U+2220` → 45 (used for angular dimensions)
- **Diameter:** `%%C25` →  $\emptyset 25$  (commonly used for reinforcement or pipes)
- **Degree-Minute-Second:** `30%%D15'20"` →  $30^\circ 15' 20''$  (for slope or direction)

### Essential Calculations

#### 1. Ground Coverage Ratio (GCR):

$$\text{GCR (\%)} = \frac{\text{Ground Floor Built-up Area}}{\text{Total Plot Area}} \times 100$$

#### 2. Floor Area Ratio (FAR):

$$\text{FAR} = \frac{\text{Total Built-up Area (All Floors)}}{\text{Total Plot Area}}$$

#### 3. Maximum Buildable Area:

$$\text{Max Built-up Area} = \text{Plot Area} \times \text{FAR}$$

#### 4. Maximum Ground Coverage:

$$\text{Max Ground Coverage} = \text{Plot Area} \times \frac{\text{GCR}}{100}$$

#### 5. Minimum Open Space:

$$\text{Open Space} = \text{Plot Area} - \text{Ground Coverage}$$

#### 6. Number of Floors (approximate):

$$\text{Number of Floors} \approx \frac{\text{Total Allowed Built-up (FAR)}}{\text{Max Ground Coverage (GCR)}}$$

#### 7. Parking Space per Vehicle:

$$\text{Standard Car Space} = 2.5 \text{ m} \times 5.0 \text{ m} = 12.5 \text{ m}^2$$

### Design Problem

Given:

- Plot Area = 2,000 m<sup>2</sup> (40m × 50m)
- Location = Urban Residential Zone, Kathmandu
- Allowed FAR = 2.0, GCR = 50%
- Setbacks: Front 3m, Sides 2m each, Rear 3m
- Parking Required = 1 space per 100 m<sup>2</sup>

### Solution:

#### Step 1: Maximum Total Built-up Area

$$\text{Max Built-up} = 2,000 \times 2.0 = 4,000 \text{ m}^2$$

#### Step 2: Maximum Ground Coverage

$$\text{Max Ground Coverage} = 2,000 \times 0.50 = 1,000 \text{ m}^2$$

#### Step 3: Number of Floors

$$\text{Floors} = \frac{4,000}{1,000} = 4 \text{ floors}$$

#### Step 4: Parking Requirement

$$\text{Spaces} = \frac{4,000}{100} = 40 \text{ spaces (500 m}^2\text{)}$$

#### Final Design:

- Basement: 500 m<sup>2</sup> parking (40 cars)
- Ground to 3rd Floor: 1,000 m<sup>2</sup> each × 4 = 4,000 m<sup>2</sup>
- Open Space: 1,000 m<sup>2</sup> (50%)

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### Summary & Key Takeaways

#### Critical Points:

1. **Building Codes (NBC):** Technical standards for structural safety. Compliance is mandatory.
2. **Building Bye-Laws:** Local regulations governing spatial planning, FAR, GCR, setbacks.
3. **GCR:** Controls horizontal coverage. Ensures open spaces and ventilation.
4. **FAR:** Controls total vertical construction. Regulates building volume.
5. **Always verify current regulations:** NBC codes updated periodically.
6. **Documentation is crucial:** Maintain complete architectural and structural drawings.
7. **Occupancy Certificate:** Final legal requirement before building use.

#### Best Practices:

- Start design with site analysis and regulatory review
- Calculate FAR and GCR early in design phase
- Maintain minimum setbacks and open space requirements
- Coordinate architectural and structural drawings throughout
- Use layers systematically in AutoCAD

### 💡 Best Practices (Contd.):

- Include detailed schedules (doors, windows, finishes)
- Verify all dimensions before submission
- Consult structural engineers for load calculations

### 🚫 Common Mistakes to Avoid:

- Exceeding FAR or GCR limits
- Ignoring setback requirements
- Not accounting for parking space requirements
- Using outdated NBC codes
- Mismatch between architectural and structural drawings
- Inadequate dimensioning and annotations
- Not considering fire safety for high-rises
- Starting construction without proper approvals

1. Calculate maximum buildable area for plot 800 m<sup>2</sup> with FAR 1.8 and GCR 60%
2. Design a 4-floor building on 1,500 m<sup>2</sup> plot with FAR 2.5 and GCR 45%
3. Calculate setback impact on 25m × 40m plot (Front 4m, Sides 2m, Rear 3m)
4. Determine parking requirement for 5,000 m<sup>2</sup> commercial building
5. Practice using AutoCAD symbols %%C, %%D, %%P in dimension text

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Master the fundamentals, build the future.

**Next class:** Location Map

**Disclaimer:** These notes are for educational purposes. Always verify current regulations with local authorities before implementation. Building codes and bye-laws are subject to periodic updates and local variations.