GENERAL

# analysis pushover etabs example

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## Understanding Pushover Analysis in ETABS: A Practical Example

When designing buildings for seismic regions, engineers must assess how structures will behave under progressively increasing lateral loads. One of the most effective tools for this purpose is **pushover analysis**, a simplified nonlinear method that captures the essential ductility and strength characteristics of a building. Among the most widely used structural analysis software packages, **ETABS**offers a robust implementation of pushover analysis that integrates seamlessly with its modeling, design, and detailing modules.

This article provides a comprehensive, step by step guide to performing a pushover analysis in ETABS. We will walk through the entire workflow—from creating a model, defining material and section properties, applying the pushover procedure, interpreting the results, to refining the design. By the end, you will have a clear understanding of how to set up an example that demonstrates the power of pushover analysis for seismic design and how to leverage ETABS's advanced capabilities.

## What Is Pushover Analysis?

Pushover analysis is a nonlinear static technique that simulates the progressive collapse of a structure under increasing lateral forces. Instead of applying a time dependent load history as in dynamic analysis, a pushover analysis applies a gradually increasing lateral load pattern until a target displacement (usually the design base shear or a prescribed drift limit) is achieved. The method captures:

- Inelastic behavior of materials and sections.
- Stiffness degradation due to cracking and yielding.
- Distribution of forces and moments along the height of the building.
- Potential failure mechanisms such as column yielding, shear wall failure, or frame collapse.

Because it is computationally efficient and provides insight into the building's overall strength and ductility, pushover analysis is a staple in modern seismic design, especially when used in conjunction with performance based design frameworks.

## Why Use ETABS for Pushover Analysis?

ETABS, developed by **Computers and Structures, Inc.**(CSI), is a specialized structural analysis and design tool tailored for building systems. Its strengths for pushover analysis include:

- Integrated Workflow: From model creation to design and detailing, all steps are managed within a single interface.
- Advanced Material Models: Supports nonlinear steel and concrete models, including the Steel 2010 and Concrete 2010 constitutive relationships.
- Automated Pushover Setup: The software can automatically generate load patterns, apply displacement controls, and manage iteration settings.
- Comprehensive Result Visualization: Deformation shapes, force diagrams, and energy plots can be visualized in 3D, aiding interpretation.
- Export options for Performance-Based Design (PBD) reports, which are increasingly required by building

codes.

In the following sections, we will demonstrate how to harness these features through a detailed example.

## Case Study Overview

Our example involves a 10  storey reinforced concrete (RC) tower located in a moderate seismic zone. The building has the following characteristics:

- Height: 30 /m ("H /3 /m per floor).
- Plan: 10 /m /× /10 /m square footprint.
- Primary structural system: Moment  resisting frame with shear walls at the corners.
- Material: High  strength concrete (f"c /= /30 /MPa) and deformed steel (fy /= /500 /MPa).
- Design Code: Eurocode 8 (EN 1998  1) for seismic design, with performance objectives at the ductile level.

We will use this model to illustrate how to perform a pushover analysis in ETABS, interpret the results, and refine the design.

## Step 1: Building the ETABS Model

### 1.1 Setting Up the Model

Open ETABS and create a new model. Select the **Reinforced Concrete** structural type, and specify the **Eurocode 8** design standard. Define the **gravity load combination** and the **seismic load combination**according to the code.

### 1.2 Defining the Geometry

Use the **Floor** tool to create ten horizontal planes at elevations of 3 /m, 6 /m, …, 30 /m. For each floor, place vertical columns at the four corners and along the perimeter, and add shear walls on the exterior faces. Use the **Beam**tool to create horizontal members connecting the columns.

### 1.3 Assigning Material Properties

Under **Materials**, define:

- Concrete – f"c /= /30 /MPa, density /= /25 /kN/m³, and the Concrete 2010 constitutive model.
- Steel – fy /= /500 /MPa, E /= /200 /GPa, and the Steel 2010 model.

### 1.4 Defining Section Properties

Create rectangular section templates for columns and walls. For columns, use a 600 /mm /× /600 /mm cross  section with 8 mm reinforcement. For walls, use 300 mm thick walls with 12 mm reinforcement. Assign these sections to the corresponding members.

### 1.5 Applying Loads

Define the **gravity loads** (dead and live) and the **seismic load combinations** following Eurocode 8. For the seismic analysis, specify the **ground motion parameters**(spectral acceleration, damping ratio, etc.) based on the site's seismic hazard.

## Step 2: Configuring the Pushover Analysis

### 2.1 Choosing the Pushover Method

Navigate to **Analyze !' Pushover Analysis !' New**Select the **Displacement Control**method, which applies a

prescribed lateral displacement at a chosen location (e.g., the roof or a specific floor). For our example, we will use a roof displacement of 30 /mm, corresponding to a 1% drift at the top floor.

### 2.2 Defining the Load Pattern

ETABS automatically generates a lateral load pattern based on the selected displacement. You can also manually define the load pattern if you wish to simulate a specific ground motion shape. For simplicity, we will use the default pattern.

### 2.3 Setting Nonlinear Options

Under **Nonlinear Options**, enable:

- Material Nonlinearity – to capture concrete cracking and steel yielding.
- Geometric Nonlinearity – to account for P 9B Vf`ects.
- Load Control – to limit the applied load increment per step.

Adjust the **step size** to ensure convergence. A typical starting step is 0.1 /% of the target displacement.

### 2.4 Defining the Target Displacement

Specify the target displacement as 30 mm at the roof. ETABS will incrementally increase the lateral load until this displacement is reached. The software will record the base shear, story drifts, and internal forces at each step.

### 2.5 Running the Analysis

Click **Run**to start the pushover analysis. ETABS will iterate through load steps, updating the stiffness matrix, applying the new load, and solving for displacements. The process continues until the target displacement is achieved.

## Step 3: Interpreting the Results

### 3.1 Base Shear vs. Drift

After the analysis completes, open the **Base Shear vs. Drift**plot. This curve shows how the base shear increases with drift. The slope of the curve indicates the structure's stiffness, while the peak represents the ultimate capacity. For our example, the curve rises linearly up to 15 /kN, then levels off as the columns yield.

### 3.2 Deformation Shape

View the **Deformation Shape**at the final step. The model should display a smooth, sinusoidal shape typical of a well damped frame. Notice any localized deformations—e.g., a sudden bending in a specific column—indicating a potential failure point.

### 3.3 Story Drifts

Check the **Story Drift** values. For seismic design, drifts should remain below the code prescribed limits (e.g.,

### 3.4 Force Distribution

Open the **Force Diagrams**for key members. Observe how the axial forces in columns increase with drift. The shear walls should carry most of the lateral load, while the frame members provide additional stiffness. If any member shows forces exceeding its design capacity, redesign is required.

### 3.5 Energy Dissipation

ETABS can plot **Energy Dissipation**versus drift. This metric is useful for performance based design, as it indicates how much energy the structure can absorb before reaching the target drift. A higher energy dissipation implies

greater ductility.

## Step 4: Refining the Design

### 4.1 Identifying Weaknesses

From the results, suppose the 5th floor column shows excessive bending. This could be due to insufficient reinforcement or a short column height. Similarly, if a shear wall exhibits high shear stresses, it may need additional reinforcement.

### 4.2 Modifying the Model

Adjust the problematic members:

- Increase column cross  section or add more reinforcement.
- Increase wall thickness or add diagonal bracing.
- Introduce moment  resisting connections between walls and columns.

Re  run the pushover analysis to verify that the modifications improve performance.

### 4.3 Iterative Process

Pushover analysis is an iterative tool. After each modification, re  analyze to confirm that:

- Base shear capacity has increased or remains sufficient.
- Story drifts stay within limits.
- No new failure mechanisms appear.

## Step 5: Linking Pushover Results to Design Codes

### 5.1 Eurocode 8 Compliance

Eurocode 8 requires that the ultimate drift (<b• for a ductile structure should not exceed 1.0 % of the building height. In our example, the ultimate drift is 0.3 /% of 30 /m (i.e., 0.09 /m), well below the limit.

### 5.2 Performance-Based Design (PBD)


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