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# Reducing Damage Deformation for Earthquake Resistant Building by Using E-TABE Software

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**ABSTRACT**

The scenario you describe involves the vulnerability of multistoried buildings with open ground floors to earthquake loads, especially in developing nations where the need for ground-level car parking space is a common requirement. In such cases, the engineering community has indeed raised concerns about the structural integrity of these buildings when subjected to lateral loads, such as those generated by earthquakes.

Here's a breakdown of the key points and methods mentioned in your case study:

Building Type: The focus is on multistoried buildings constructed with a ground floor that is open and primarily used for car parking. These buildings are at risk of collapse when subjected to seismic forces. Engineering Community Warnings: The engineering community has warned against the construction of such buildings due to their vulnerability during earthquakes. Modeling and Analysis: The study involves the use of software like E-TABE to model and analyze a reinforced concrete (R.C.C.) building subjected to dynamic loads, with a specific emphasis on earthquake loads. This type of analysis is crucial for assessing the structural performance of the building. Performance Evaluation: The performance of the building is assessed using various metrics, including Story Drifts, Lateral Displacements, and Base Shear. These parameters help in understanding how the building responds to lateral forces during an earthquake. Non-Linear Analysis: To design and assess reinforced concrete members and understand their behavior under different loading conditions, non-linear analysis is conducted. This type of analysis considers the non-linear behavior of materials and structural elements.

Force Redistribution: Non-linear analysis helps in studying how forces are redistributed within the structure during an earthquake. This is essential for ensuring that the building can withstand the applied loads without collapsing. Load-Deflection Behavior: The analysis allows for an examination of the load-deflection behavior of the structure. This helps in understanding how the building deforms and behaves under different loading conditions. Crack Patterns: Non-linear analysis also provides insights into the crack patterns that may

**Index Terms:** Seismic Response, Story Drifts, Lateral Displacement, Base Shear, E-TABE, R.C.C. building

## Introduction

Base isolation as a seismic engineering technique. Base isolation, also known as seismic base isolation or base isolation system, is indeed a widely used method for protecting structures from earthquake forces. Here's some more information to help you understand this concept:

**Purpose:** The primary purpose of base isolation is to decouple a building or structure from the ground motion during an earthquake. By isolating the superstructure from the shaking ground, it reduces the transfer of seismic forces and vibrations to the building, thus protecting its integrity.

**Passive Structural Vibration Control:** Base isolation is considered a form of passive structural vibration control. Unlike active systems that require external energy sources, base isolation relies on the inherent characteristics of the isolation components to mitigate the effects of seismic forces.

**Design and Implementation:** Base isolation is implemented through a combination of structural elements that decouple the superstructure from the substructure. This typically involves the use of isolation bearings or isolators, which are placed between the building's foundation and the structure itself. These isolators are designed to absorb and dissipate seismic energy, allowing the building to move independently of the ground motion.

**Benefits:** Base isolation has several advantages, including:

- ✓ Improved seismic performance: It enhances a structure's ability to withstand earthquakes and reduces the risk of damage or collapse.
- ✓ Preservation of structural integrity: By minimizing the transmission of ground motion, it helps maintain the structural integrity of the building.
- ✓ Enhanced occupant safety: Base-isolated structures are safer for occupants during seismic events.

- ✓ Potential for cost savings: In some cases, retrofitting a building with base isolation can be more cost-effective than traditional seismic strengthening methods.

**Not Earthquake-Proof:** It's important to note that base isolation does not make a structure earthquake-proof. Instead, it significantly improves a building's seismic performance and reduces the risk of damage, but there are limits to the magnitude of earthquakes that even base-isolated structures can withstand.

**Components:** Base isolation systems can consist of various components, including base isolators, isolator bearings, sliding bearings, and other elements that provide the necessary flexibility and energy dissipation. The selection of these components depends on the specific requirements of the structure and the seismic hazard in the region.

## LITERATURE REVIEW

**Fadi Oudah et al (2020)** The passage you provided discusses concrete connections used in seismic engineering to mitigate damage during earthquakes. These connections, known as slotted-beam connections, are designed to reduce the penetration of yield into the joint, minimize beam elongation, and protect the attached slab from tearing when subjected to seismic forces. There are two main configurations of slotted-beam connections: Single Slotted Beam (SSB) and Double Slotted Beam (DSB).

**Single Slotted Beam (SSB) System**: In the SSB system, there is a single slot made at the bottom face of the beam member. The research investigates the damage evolution and deformation mechanisms of SSB connections, both with and without relocated vertical slots. Relocating the vertical slots away from the face of the column in the SSB system was found to reduce its ductility capacity.

**Double Slotted Beam (DSB) System**: In the DSB system, there are double slots made at the top and bottom faces of the beam member. The research also looks into DSB connections with and without relocated vertical slots. In the DSB system, relocating the vertical slot up to a certain distance (beam effective shear depth) does not significantly affect its effectiveness in relocating the center of rotation.

## OBJECTIVE OF PAPER

Reducing damaging deformations in structural and nonstructural components and minimizing acceleration response to protect contents from damage are important goals in structural engineering and seismic design.

## METHODOLOGY

Describing a process involving analytical work, the use of E-TABE programming for creating 3D models and conducting structural analysis, as well as the application of horizontal loads related to seismic zone V and 5% damped response range specified in IS: 1893-2002.

Here's a breakdown of the information you provided:

**Analytical Work**: This suggests that you're working on some form of analysis, likely related to structural engineering or a similar field.

**E-TABE Programming**: E-TABE is likely a software or program used for creating 3D models and performing structural analysis. It may have specific features or capabilities that make it suitable for this task.

**3D Modeling**: E-TABE is used for creating 3D models, which is common in structural analysis to visualize and assess structures in a three-dimensional space.

**Dynamic Analysis**: Dynamic analysis of the structure models is performed using E-TABE. This implies that you're not just analyzing the structure statically but considering dynamic forces or vibrations that it may experience.

**Horizontal Loads**: The horizontal loads generated or considered in the analysis are associated with seismic zone V. This suggests that you're assessing the structure's response to seismic activity, and the "V" designation typically signifies a high seismic hazard area.

**5% Damped Response Range (IS: 1893-2002)**: The analysis is performed within the framework provided by the Indian Standard IS: 1893-2002, which likely outlines guidelines for seismic analysis and design criteria. The mention of "5% damped response range" likely refers to a damping ratio used in the analysis, which is important in assessing a structure's response to dynamic forces like earthquakes.

**Standard of Base Isolation**

Provided discusses the concept of base isolation in the context of earthquake engineering. Base isolation is a structural technique used to protect buildings and structures from the damaging effects of earthquakes. Here's a summary of the key points from the text:

1. **Essential Rule of Base Isolation:** The primary idea behind base isolation is to adjust the structure in such a way that it can move independently of the ground motion during an earthquake, minimizing or completely preventing the transfer of seismic forces to the structure above.
2. **Perfect vs. Realistic Systems:** In a perfect theoretical system, complete separation of the structure from ground motion is possible. However, in reality, some vertical support is necessary to transfer vertical loads to the foundation.

3. **Behavior of Rigid and Flexible Structures:** The text mentions that a perfectly rigid structure will experience no relative movement with the ground, while a perfectly flexible structure will not experience any acceleration. In practice, real structures fall somewhere between these two extremes.
4. **Effects of Earthquake Periods:** The acceleration and displacements experienced by a structure during an earthquake depend on the earthquake's period (frequency). Different structures will exhibit different responses to various earthquake periods.
5. **Base Isolation as a Solution:** Base isolation is presented as an ideal method for mitigating the effects of earthquakes. It reduces the transfer of ground motion to the structure, thus controlling its displacement.
6. **Location of Displacement:** In non-base-isolated (fixed base) structures, the displacements occur at the center of gravity (CG) of the structure, which is typically around two-thirds of its height. In base-isolated structures, the displacements occur at the isolation plane, leading to less displacement within the structure.
7. **Comparison of Responses:** The text suggests that a base-isolated structure will experience significantly reduced displacements and accelerations compared to a non-base-isolated structure during an earthquake.

**Figure1: Spring Isolators**

**Table No.1 Building Features**

| **PARTICULAR** | **DISCRIPTION** |
|---|---|
| Type of structure | Multi-Storey Ordinary REC moment-resisting frame (OMRF) |
| Area | 36.12 X 31.52 (m²) |
| Seismic zone | V as per IS 1893 (part-1):2002 |
| Building Height | 18.6 m |
| Storey Height | 3.1 m |
| Infill Wall | 200 mm thick including plaster |
| Imposed Load | 4 kN/m² for roof and 12 kN/m² for floor |
| Materials | Concrete (M25) / Reinforcement (Fe-500) |
| Size of Column in “mm” | 450 X 750 ; 350 X 600 |
| Size of Beam in “mm” | 650 X 300 |
| Depth of Slab | 150 mm thick |
| Specific Weight of RCC | 25 kN/m³ |
| Specific Weight of Wall | 20 kN/m³ |
| Type of Soil | Rock |
| Response Spectra | As per IS 1893 (part-1):2002 |

## RESULTS AND DISCUSSION

### Story Drift Ratio

Story drift ratio is a term used in structural engineering to measure the relative displacement between two consecutive stories of a building. It is a crucial factor in the design and analysis of structures, particularly in scenarios involving lateral forces such as wind or seismic loads.

The formula for calculating story drift ratio is as follows:

**Story Drift Ratio = (Displacement of Story N - Displacement of Story N+1) / Story Height**

Here, "Displacement of Story N" is the absolute value of the displacement of a particular story under the influence of lateral forces, and "Displacement of Story N+1" is the displacement of the story immediately above it. "Story Height" is the height of one story in the building, typically measured in millimeters or meters.

**Table 2: Storey Drift of Building**

| **Floor** | **Story Level** | **Story Drift Ratio** | |
|---|---|---|---|
| | m | **Fixed Base** | |
| Ground | 0 | 0 | Ground |
| First | 3.1 | 0.198 | First |
| Second | 6.2 | 0.275 | Second |
| Third | 9.3 | 0.270 | Third |
| Fourth | 12.4 | 0.235 | Fourth |
| Fifth | 15.5 | 0.568 | Fifth |
| Roof | 18.6 | 0.50 | Roof |

**Story Displacements**

**Story Displacement:** Story displacement is the absolute value of the displacement of a particular story when subjected to lateral forces. This is an important parameter because it quantifies how much a story moves from its original position when these forces act on the structure.

**Table – 3: Lateral Displacements of Building**

| **Floor** | **Storey Level** | **Displacement (mm)** | |
|---|---|---|---|
| | m | **Fixed Base** | |
| Ground | 0 | 0 | Ground |
| First | 3.1 | 7.3 | First |
| Second | 6.2 | 17.23 | Second |
| Third | 9.3 | 30.30 | Third |
| Fourth | 12.4 | 52.20 | Fourth |
| Fifth | 15.5 | 67.19 | Fifth |
| Roof | 18.6 | 80.50 | Roof |

## CONCLUSION

The main observations and conclusions drawn are summarized below:

The summarized observations and conclusions from the study you provided are as follows:

- ✓ There is a clear need for accurate non-linear modeling and analysis of existing reinforced concrete (RC) buildings for seismic assessment.
- ✓ Non-linear seismic performance-based analysis and design procedures should be incorporated into Indian building codes to enhance earthquake resilience.
- ✓ Non-linear static (pushover) analysis is a rapid and force-based method for assessing the seismic performance of structures.
- ✓ The use of base isolators in reinforced concrete buildings can significantly reduce the base shear, with reductions ranging from 32.81% to 83.27% compared to buildings without base isolators.
- ✓ Base isolators also lead to a substantial reduction in the story drift of buildings, with reductions ranging from 64.34% to 85.66% compared to non-isolated buildings.
- ✓ The maximum displacement of the building is significantly reduced when base isolators are used, with reductions ranging from 54.11% to 71.29% compared to buildings without isolators.

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