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Analysis and Design of High Rise RCC Building with a Comparative Study of Vibration Controlling Damper

Numerical Investigation of Structural Response and Vibration Control

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Abstract - High-rise reinforced concrete RCC buildings are exposed to lateral actions due to wind and earthquakes. As building height increases, lateral displacement, inter-storey drift and floor acceleration become important response quantities. Supplemental energy-dissipation devices, including viscous fluid dampers VFDs, may be used to modify the dynamic response of building structures. This paper presents a comparative numerical study of a high rise RCC residential building modelled in ETABS. Two configurations are considered: a conventional building without supplemental dampers and a modified building incorporating VFD link elements. The comparison is intended to examine storey displacement, inter-storey drift and base shear under corresponding analysis conditions. The project model has shown a reduction in lateral displacement after the introduction of VFDs; however, the final magnitude must be established from verified, storey-wise ETABS output. The paper therefore provides the analysis framework and result tables to be completed using the actual building dimensions, damper properties, load cases and numerical results.

Keywords - G+24 building; reinforced concrete; viscous fluid damper; ETABS; seismic response; storey displacement; interstorey drift; energy dissipation.

I. INTRODUCTION

The increasing demand for residential accommodation in urban areas has encouraged vertical development and the construction of high-rise buildings. Such buildings are subjected to gravity loads as well as lateral actions caused by wind and earthquake ground motion. The structural response depends on the distribution of mass and stiffness, the dynamic characteristics of the building, the damping available in the structural system and the nature of the applied excitation. Excessive lateral movement and inter-storey deformation may affect structural and non-structural components and can influence occupant comfort. Conventional seismic design primarily relies on adequate strength, stiffness, ductility and detailing. Supplemental damping systems provide an additional mechanism for dissipating energy. Viscous fluid dampers operate through the movement of a piston relative to a cylinder containing a viscous fluid. The resulting resisting force is related to the relative velocity across the device. Experimental investigations have demonstrated the potential of fluid dampers to modify the response of building models subjected to seismic excitation [1], while later work has discussed the modelling and energy-dissipation characteristics of linear and nonlinear fluid viscous damping systems [2] The effectiveness of a VFD system is influenced by damper leveled equations, graphics, and tables are not prescribed, although the various table text styles are provided. The formatter will need to create these components, incorporating the applicable criteria that follow. properties, placement, supporting braces and connections, as well as the dynamic properties of the host structure. Design and layout considerations have also been examined in studies of existing multi-storey buildings retrofitted with fluid viscous dampers [3]. Accordingly, the present work compares a G+24- storey RCC residential building model without additional dampers with a corresponding model incorporating VFDs.

II. AIM AND SCOPE

The aim is to evaluate the influence of Viscous Fluid Dampers on the lateral response of a G+24-storey RCC residential building through comparative numerical analysis in ETABS.

The study objectives are:

- to develop and analyse a three-dimensional G+24-storey RCC building model to establish the response of the conventional building without additional dampers;
- to incorporate suitable VFD link properties and an identified damper arrangement in the analytical model;
- to compare storey displacement, inter-storey drift and base shear under corresponding analysis conditions; and
- to quantify response changes using verified numerical output.

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The scope of this paper is limited to the analytical configurations and loading cases actually completed. Maintaining the Integrity of the Specifications

III. BUILDING DESCRIPTION AND NUMERICAL MODEL

A. Building configuration

The structure considered is a G+24-storey RCC residential building. The architectural layout was prepared in AutoCAD and represented in ETABS 22 using the building grid and storey data. The structural model includes the beams, columns, slabs and structural walls, where provided in the adopted design.

The final manuscript must state the actual dimensions and member properties used in the analysed ETABS file. Any value not verified from the model or design calculations should not be reported as a project fact.

B. Loading and analysis assumptions

The model considers self-weight and other permanent actions, imposed residential loads, wind actions and earthquake actions as applicable to the project design basis. The adopted parameters include the site basic wind speed, terrain category, seismic zone, soil type, importance factor, response reduction factor, damping assumptions, mass source and load combinations.

Table 1 - Building Parameters	
No. of Storeys	G + 23 (24 TOTAL)
Typical Floor Height	3.0 m
Total Building Height	3X24m
Plan Dimensions	25mX15m
Support Conditions	Fixed Support
Slab Thickness	150 mm
Beam Size	300 mm x 600 mm
Column Size (Bottom)	300 mm x 1000 mm
Column Size (Top)	300 mm x 1000 mm
Shear Wall Thickness	150 mm
Foundation Type	Isolated Footings / Raft (TBD)

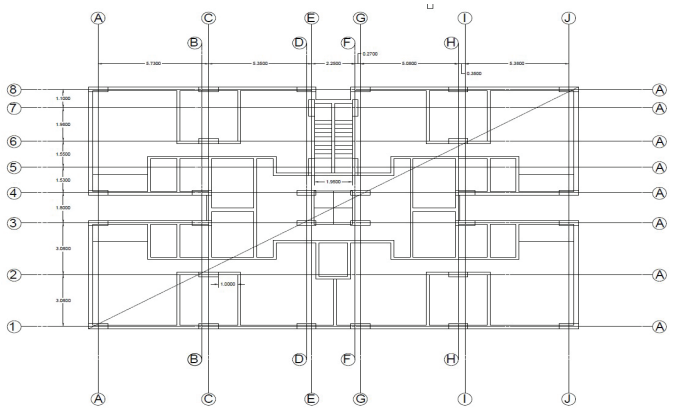


Figure 1 Plan showing column and beam positions

Table 2 - Analysis and loading information	
Item	**Value used in the project**
Seismic design standard	IS 1893 (Part 1):2016, including applicable amendments
Wind design standard	IS 875 (Part 3):2015, including applicable amendments
Seismic zone	Zone III
Zone factor (Z)	0.16
Site class / Soil type	As per geotechnical investigation (Type I / II / III)
Basic wind speed (Vb)	39 m/s

IV. VFD MODELLING AND COMPARATIVE METHODOLOGY

A. Conventional and damper-equipped models

Two ETABS configurations are used for comparison. Model A is the conventional building without supplemental VFDs. Model B retains the same building geometry, material properties, mass source and corresponding loading assumptions, with VFD exponential damper link elements added at the selected structural locations. The damper locations, number of devices, connection arrangement and orientation must be illustrated in the final paper using the actual ETABS model views.

B. Damper force–velocity relationship

For a nonlinear viscous damper, the idealised force–velocity for exponential damper
relationship may be expressed as

$$Fd = Cd\,|vd\,|\alpha\ \mathrm{sgn}(vd), \quad \text{eqn (1)}$$

where Fd is the signed damper force, Cd is the damping coefficient, vd is the relative velocity across the damper and α is the velocity exponent. For $\alpha = 1$, the idealised relationship is linear; for an exponent different from unity, the relationship is nonlinear. The units of Cd depend on the force and velocity units and on the value of α.

The final paper must identify the exact link formulation selected in ETABS. If an exponential Maxwell link is used, the series spring stiffness and the nonlinear viscous properties must be reported. The coefficient, exponent, stiffness, force capacity and stroke must be based on a documented device specification or a justified design procedure; they must not be selected solely by trial without explanation.

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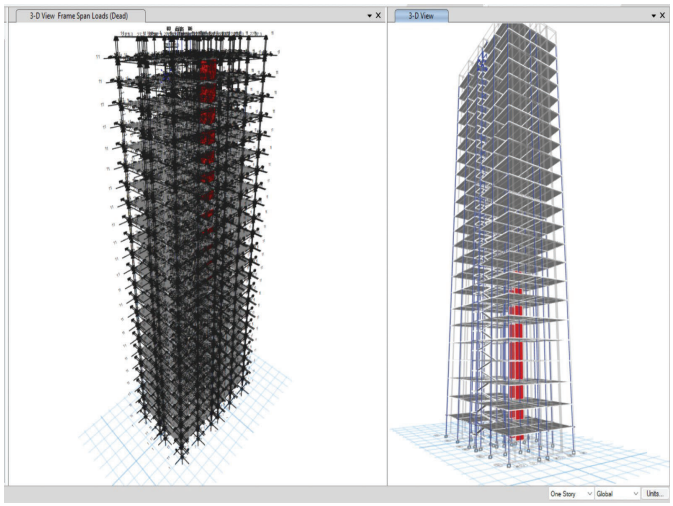


Figure 2 Three Dimensional image without VFD

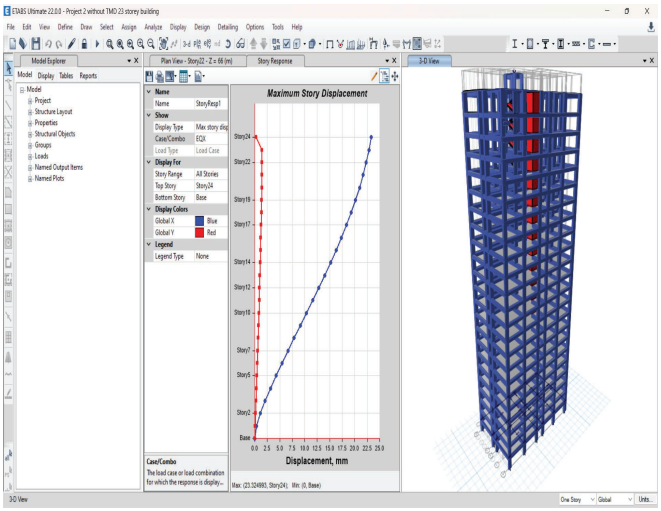


Figure 3 Displacement graph

C. Analysis procedure

The conventional model is analyzed first and its response is recorded as the baseline. The VFD-equipped model is then analyzed using the corresponding load cases and settings. For nonlinear exponential damper properties, a nonlinear direct integration time-history procedure is generally required to capture the nonlinear velocity-dependent damper behaviour. A response-spectrum result should not be presented as if it directly captures the full nonlinear force–velocity history of an exponential damper. If a linear equivalent representation or a different analysis procedure is used, its assumptions and limitations must be stated explicitly.

The comparison is made using like-for-like results: the same direction, storey, loading or ground-motion record, record scaling, mass source and response measure. The global building model and any changes to brace or connection stiffness are documented so that the influence of the damper system can be interpreted correctly.

V. RESULTS AND DISCUSSION

A. Storey displacement

The ETABS model comparison performed to date indicated a lower lateral displacement in the VFD-equipped configuration than in the conventional configuration for the compared case. The final manuscript should report the actual displacement values and the corresponding loading case, direction and storey. Storey-wise displacement profiles should be plotted for both configurations to show whether the response change is distributed along the height or concentrated at particular levels.

The percentage reduction at a corresponding storey may be
calculated as – $R\Delta = \Delta 0 - \Delta d/\Delta 0 \times 100$
where $\Delta 0$ and Δd are the displacement magnitudes without and with VFDs, respectively. The calculation is meaningful only when the values correspond to the same storey, direction, load case or record, and response measure.

B. Inter-storey drift

Inter-storey drift is the relative displacement between adjacent floors. For storey i, the drift displacement is $\delta i = ui - ui{-}1$, where ui and $ui{-}1$ are the lateral displacements of adjacent floors. The drift ratio is obtained by dividing the absolute drift displacement by the corresponding storey height. The drift profiles of Model A and Model B should be compared in each principal direction. The maximum value, location and

Inter story drift ratio = $\theta i = |\Delta i| / hi$

hi = height of storey i. Drift ratio is dimensionless; it has no physical unit.

Table No 3 – Displacement parameters

Sr. No.	Structural response parameter	Without VFD	With VFD	Percentage change
1	Maximum X-direction displacement	23.32	19.91	14.62264151
2	Maximum Y-direction displacement	26.85	19.95	25.69832402
3	Maximum inter-storey drift	0.000414	0.000339	18.11594203

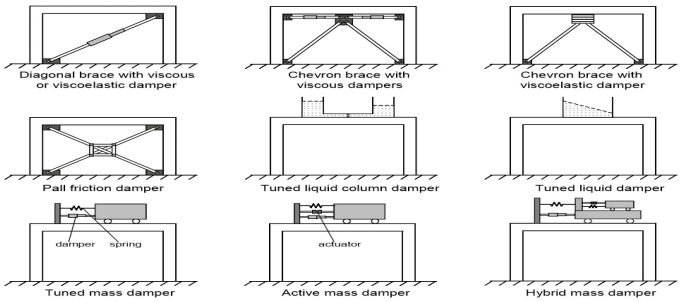


Figure 4 VF Damper & Other Damper

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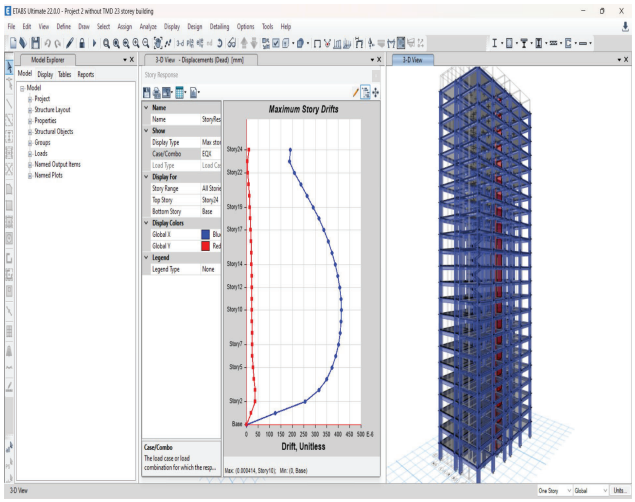


Figure 5 Story drift of structure

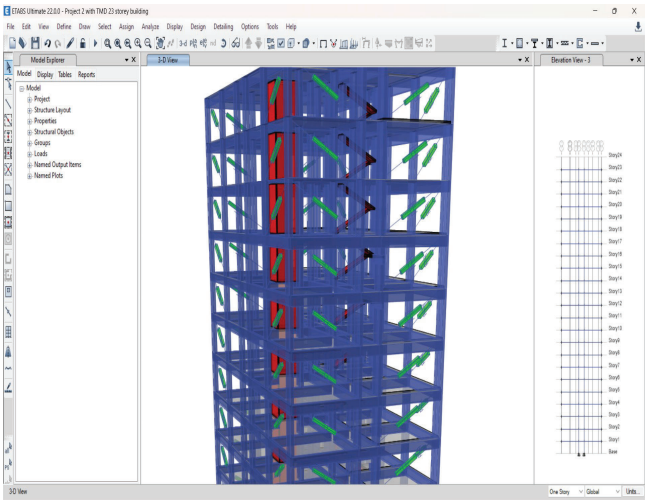


Figure 6 Placement of VFD in structure

C. Base shear

Base shear is the total horizontal reaction transferred to the supports for a specified analysis case or response measure. The base shear values of both models should be extracted and compared for corresponding directions and analysis conditions. For time-history analysis, the paper must specify whether the reported value is a peak resultant, a peak of a signed time history response, or another defined measure. An increase or decrease in base shear should be interpreted together with displacement, drift and member-force demands; a reduction base shear is not automatically equivalent to improved

Table No 4 – Base shear Reduction

Sr No	Particulars	Without VFD	With VFD
1	Maximum FX	3.08E-08	4.704
2	Minimum FX	-1103.36	-737.65
3	Maximum absolute FX	1103.36	737.65
	Reduction (%)	—	**33.15%**

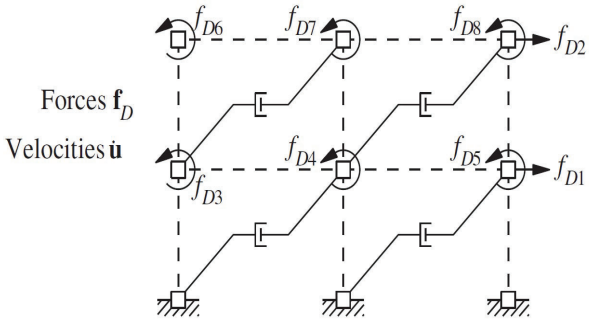


Figure 7 MDOF – of Simple Structure

D. Discussion

The preliminary observation of reduced lateral displacement after adding VFD link elements is consistent with the expected role of supplemental damping, provided the link properties are activated and represented correctly in the selected analysis case. The final discussion must connect the observed changes to the damper formulation, location, force and deformation demands, and the characteristics of the excitation. It should also identify any response parameter that increased, any storey where drift remained critical, and any limitations of the modelling assumptions. Numerical percentage claims must be based on the completed and verified ETABS output.

VI. CONCLUSION AND FURTHER WORK

The study presents a comparative numerical framework for investigating a G+24-storey RCC residential building with and without Viscous Fluid Dampers. The ETABS model comparison performed to date has indicated a reduction in lateral displacement after the introduction of damper links for the case examined. This observation supports further quantitative assessment, but the magnitude and generality of the reduction must be established by reporting the exact analysis case, displacement values and corresponding percentage change. The final paper should add verified comparisons of inter storey Drift and base shear, together with damper force and deformation output where available. Further work may include sensitivity studies on damping coefficient and velocity exponent, comparison of damper layouts, additional ground-motion records, and experimental testing of a properly scaled prototype. Experimental validation should be reported only after testing is completed and should compare measured results with a numerical model of the prototype under compatible conditions.

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