DYNAMIC ANALYSIS OF DOUBLE SKIN FAÇADE BUILDING WITH MULTIPLE MASS DAMPERS

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Abstract - Double façade systems consisting of two layers of curtain wall connected by low axial stiffness metal connectors wherein air flows through the intermediate cavity. One of the technique to resist seismic effect on the building is by providing double façade system. DSF systems are more effective environmental mediators than conventional single skin façade systems. Therefore their use for tall buildings has increased despite their higher initial costs. In structural aspect, to control the vibration of the building, flexible connectors are provided between the double skins. As a result, the DSF outer skin moves back and forth, thus vibration of the primary structure, is reduced significantly. However, the excessive vibration of the DSF outer skin is a serious limitation. To overcome this challenge, additional small masses are inserted into the DSF cavity and act as distributed tuned mass dampers. In this study an intensive research is taking place in structural Engineering field to control the vibration of the building under lateral load. So a study on double façade system, tuned mass damper to control the vibration is inevitable. This paper focuses the comparative study on multiple and single tuned mass dampers in double skin façade building.

Key Words: Tall buildings, double skin facades, tuned mass damper, single skin façade, vibration

1. INTRODUCTION

One of the technique to resist seismic effect on the building is by providing Double Façade System. Double façade systems consisting of two layers of curtain wall connected by low axial stiffness metal connectors wherein air flows through the intermediate cavity. Tuned Mass Dampers are most reliable system to control vibration in high rise building. TMD's are usually provided as a large single unit at the top centre of the building. Now a day, multiple TMD are used to control earthquake induced motion of high rise buildings. Various façade systems, such as glass/metal curtain-walls, stone panels and precast concrete panels, are used to clad tall buildings. Generally, most façade systems are composed of several layers. In conventional cases, there are no substantial gaps between the facade layers. The double skin façade (DSF) system, which has a substantial cavity space between the façade layers, has been obtaining increased interest due to its energy efficiency by enhanced performance as an environmental mediator. While many studies have been carried out regarding environmental/energy aspects of the DSF system, no substantial research has been performed on the structural capability of the DSF system. In tall buildings, especially at their upper levels, excessive movement and acceleration can cause serious human discomfort problems. This paper investigates tall building dynamic motion control by introducing energy dissipating mechanisms within the DSF cavities.

2. Modeling of structures

The building consists of Ground +9 stories. The beam and column layouts are first fixed and the modeling is done using software ETABS 2016. For analysis, the dead loads and live loads is calculated as per IS: 875 (Part 1 and 2), seismic load is calculated by referring IS 1893 (Part1):2002 and wind loads are calculated from IS: 875 (Part 3)-1987. The concrete mix used is M30and steel used is Fe 415 grade. Size of the beam provided is 250mmx350mm and columns size is 300mmx300mm.thickness of slab provided is 120mm. Aluminium frame and glass panels are connected by flexible connectors.

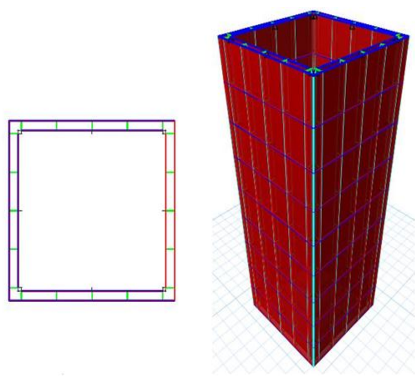


Fig.1: facade

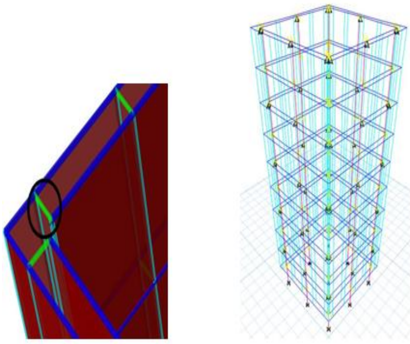


Fig.2 : Flexible connectors

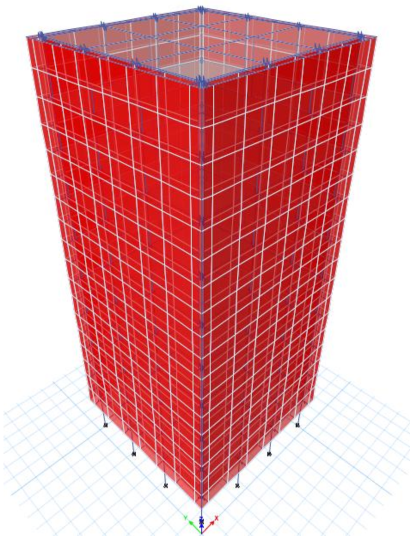


Fig. 3: 3D- View of Structure

3. ANALYSIS

Frequency response analysis is a structural analysis and is the calculation of the response of a building structure to earthquakes. In the response spectrum method of analysis, multiple mode of vibrations were used in the frequency domain. The response of a multi-storey structure is defined as a combination of various special modes i.e. in a vibrating string corresponds to the "harmonics".

3.1 SINGLE TMD

Mass Ratio is the Ratio of mass of damper to that of structure. Mass Ratio varied from 0.2% to 2% to find optimum damper mass. Tuning of damper is done by making damper frequency equal to structural frequency. Stiffness of damper,

$$K = m \times w_n^2$$

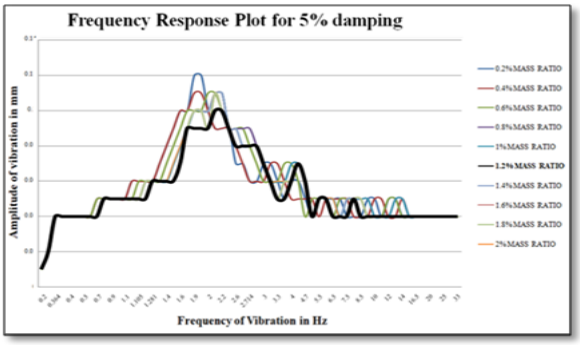
Where m - Mass of damper and w_n - Frequency of damper

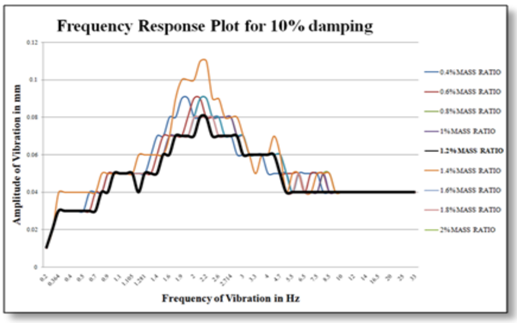
Damper frequency at various mass ratio plotted below.

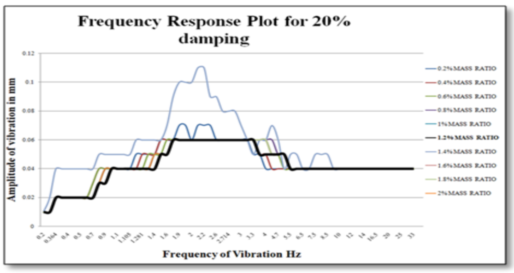
Table.1 : Stiffness & frequencies at various mass ratios

Mass Ratio (%)	Mass of Damper (kg)	Stiffnesss before Tuning (kN/m)	Stiffnesss after Tuning (kN/m)	Damper frequency before tuning (Hz)	Damper frequency after tuning (Hz)
0.2	48.73	259.73	261.14	0.372	0.371
0.4	97.45	519.46	508.34	0.367	0.371
0.6	146.18	779.18	762.52	0.367	0.371
0.8	194.91	1038.91	1005.64	0.365	0.371
1	243.63	1298.64	1257.05	0.365	0.371
1.2	292.36	1558.37	1592.24	0.367	0.371
1.4	341.09	1818.09	1857.62	0.369	0.371
1.6	389.81	2077.82	2122.99	0.371	0.371
1.8	438.54	2337.55	2388.37	0.373	0.371
2	487.26	2597.28	2653.74	0.375	0.371

Damper frequency at various mass ratio plotted below.







Vibration of building reduces up to mass ratio 1.2% and then gradually increases. ie, Vibration is least for mass of damper equal to 1.2% of the total mass of the structure.

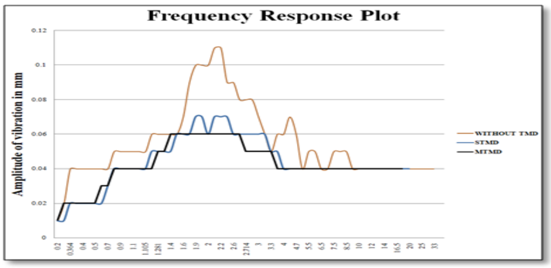
3.2 MULTIPLE TMD

From the frequency analysis of single TMD, it is clear that for the modelled building optimum mass ratio is 1.2% and optimum damping is 20%. Multiple TMD's are modelled using the optimum values. Frequency of each multiple TMD,

$$w_j = w_T \left[1+\{ j- (n+1) / 2 \}\beta / (n-1) \right]$$

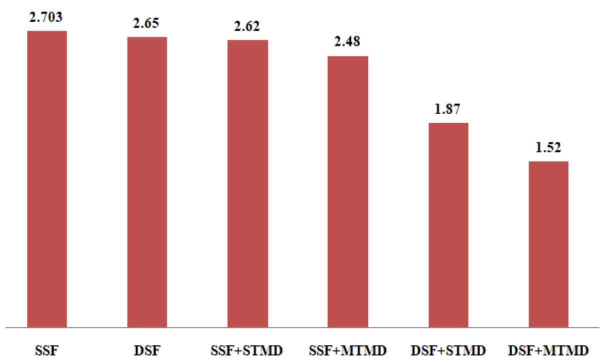
Where w_j - Natural Frequency of j^{th} damper, n - Number of multiple tuned dampers, β - Fractional Band width = 2ξ and ξ -damping ratio

Mass of each TMD = Mass of single TMD/Number of TMD's.



Using TMD's the vibration of the building reduces significantly. Multiple TMD's in DSF cavity performs better than single TMD on the RCC building.

TIME PERIOD OF VIBRATION (sec)



Time period is least for MTMD coupled DSF structure.

4. CONCLUSIONS

1. When damping ratio increases vibration of the building reduces.

2. Vibration control is better when TMD's are provided in DSF cavity rather than placing single large TMD on the building.

3.Single TMD and Multiple TMD's with 1.2% mass ratio and 20% damping ratio could reduce the response of the building to around 65% in case of single Façade structures and 72% in case of DSF structures.

4. Time period also get reduced when TMD's are provided in DSF cavity.

5. Compared to the conventional Single TMD system, usually located in the occupiable space near the top of the building, MTMD's has the substantial benefit of saving this valuable occupiable space.

6. The concept of providing very flexible connectors between the Double skins, the transmissibility of the dynamic lateral load can be reduced through them.

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