ONE-WAY TRANSLATIONAL MAGNETIC MASS DAMPER MODEL FOR STRUCTURAL RESPONSE CONTROL AGAINST DYNAMIC LOADINGS

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INTRODUCTION

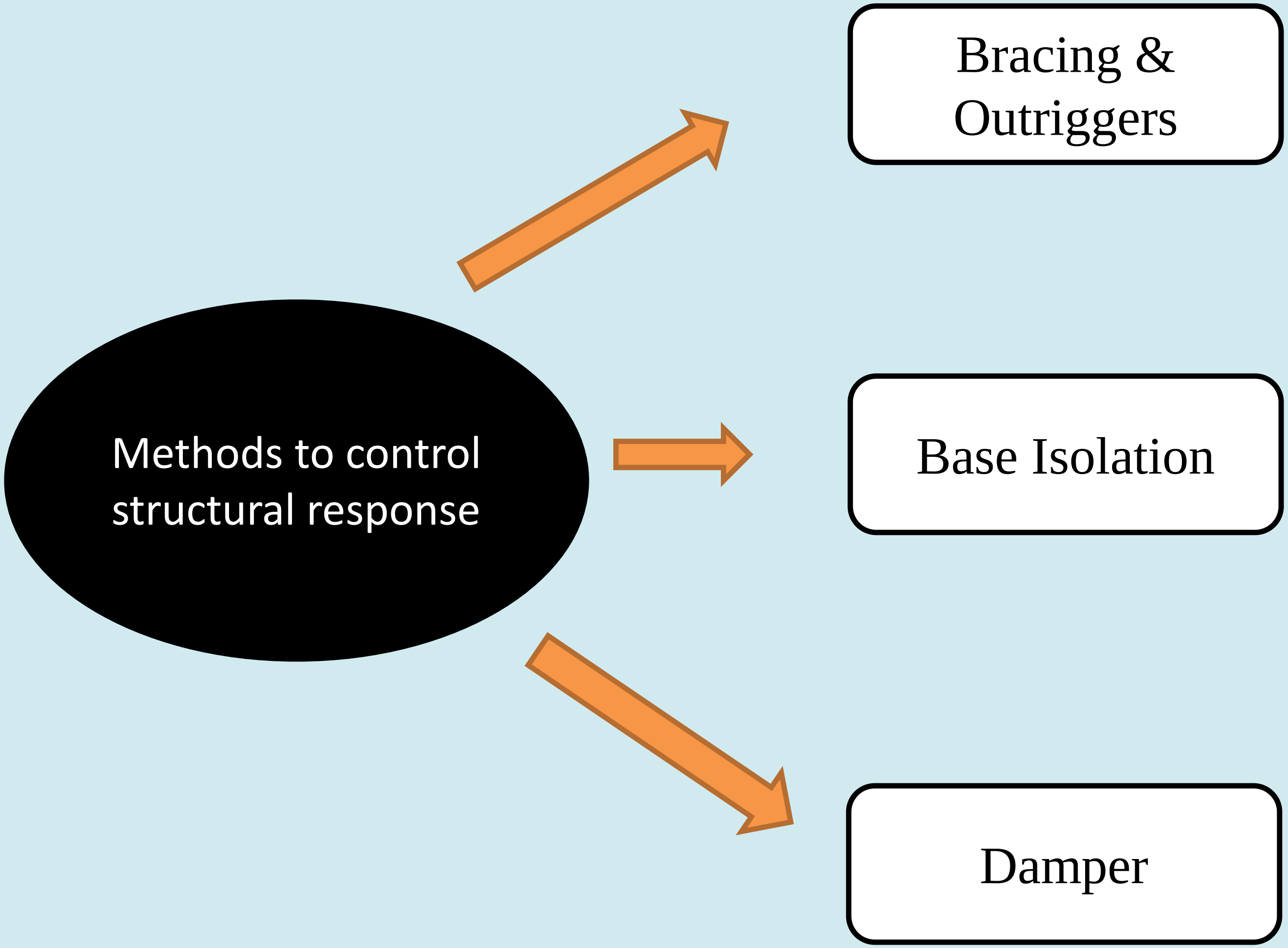
INTRODUCTION

❖ What is dynamic excitation?

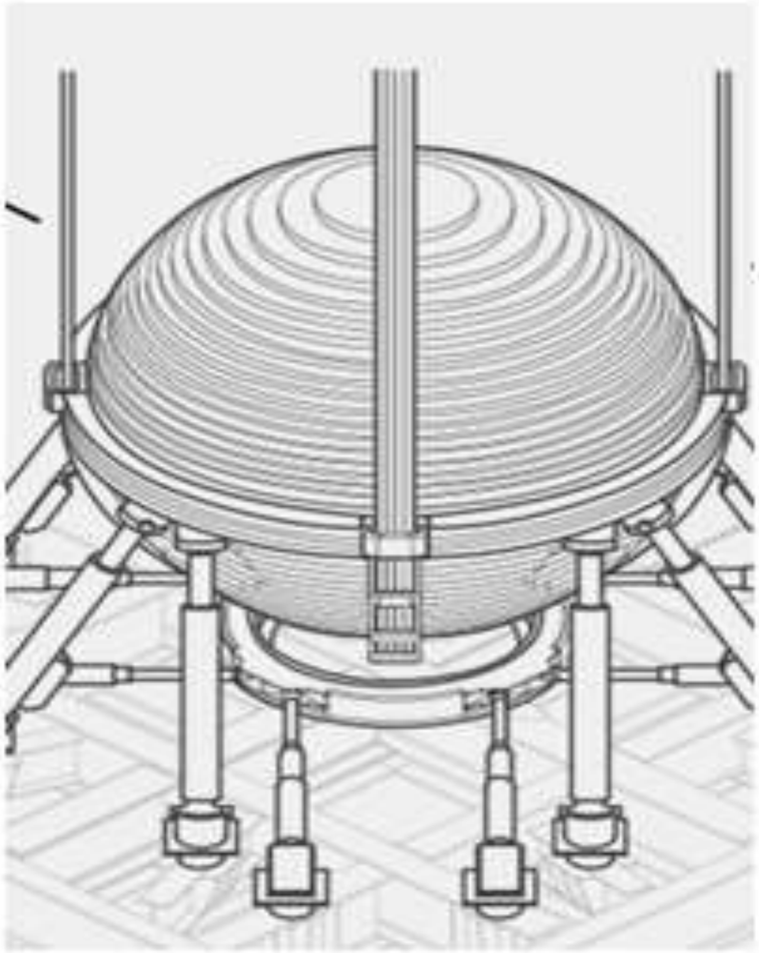
- Earthquake ground motion
- Typhoon
- Machineries

❖ What is the effect of dynamic excitation?

Additional mechanism/device installed to control structural response:
(Connor & Laflamme, 2014)



PROBLEM STATEMENT



Magnetic Mass Damper

- Comprises of mass, magnets and damper

- Use the principle of repulsive force of magnets

- The energy dissipated through the motion of the damper

OBJECTIVES

The objectives of this study are:

1. To establish the correlation between the excitation speeds of the shaking table with the displacement of the five storeys downscaled structure model.

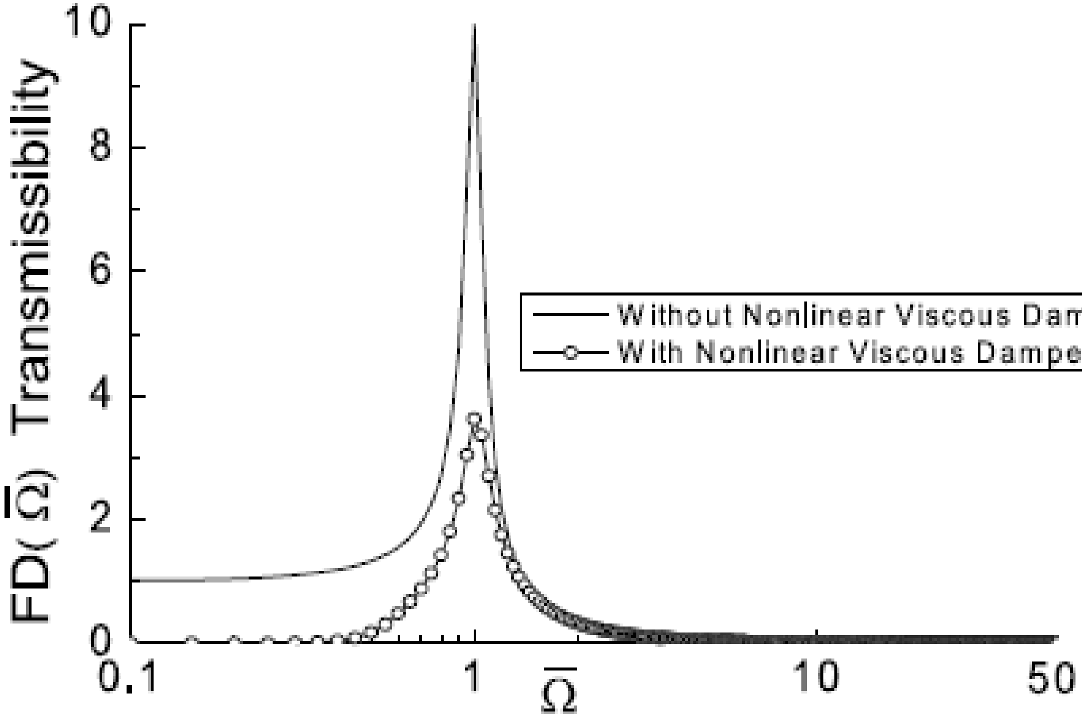
2. To investigate the influence of magnetic strength of the magnetic damper to the displacement of the five storeys downscaled structure model.

OBJECTIVES (cont..)

3. To investigate the correlation between the mass in the magnetic damper to displacement of the five storeys downscaled structure model.

4. To determine the optimization between the mass of the damper and the magnetic strength towards the displacement of the five storeys downscaled structure model.

LITERATURE REVIEW



10
8
6
4
2
0
FD($\bar{\Omega}$) Transmissibility
0.1
1
10
50
$\bar{\Omega}$
Without Nonlinear Viscous Damper
With Nonlinear Viscous Damper

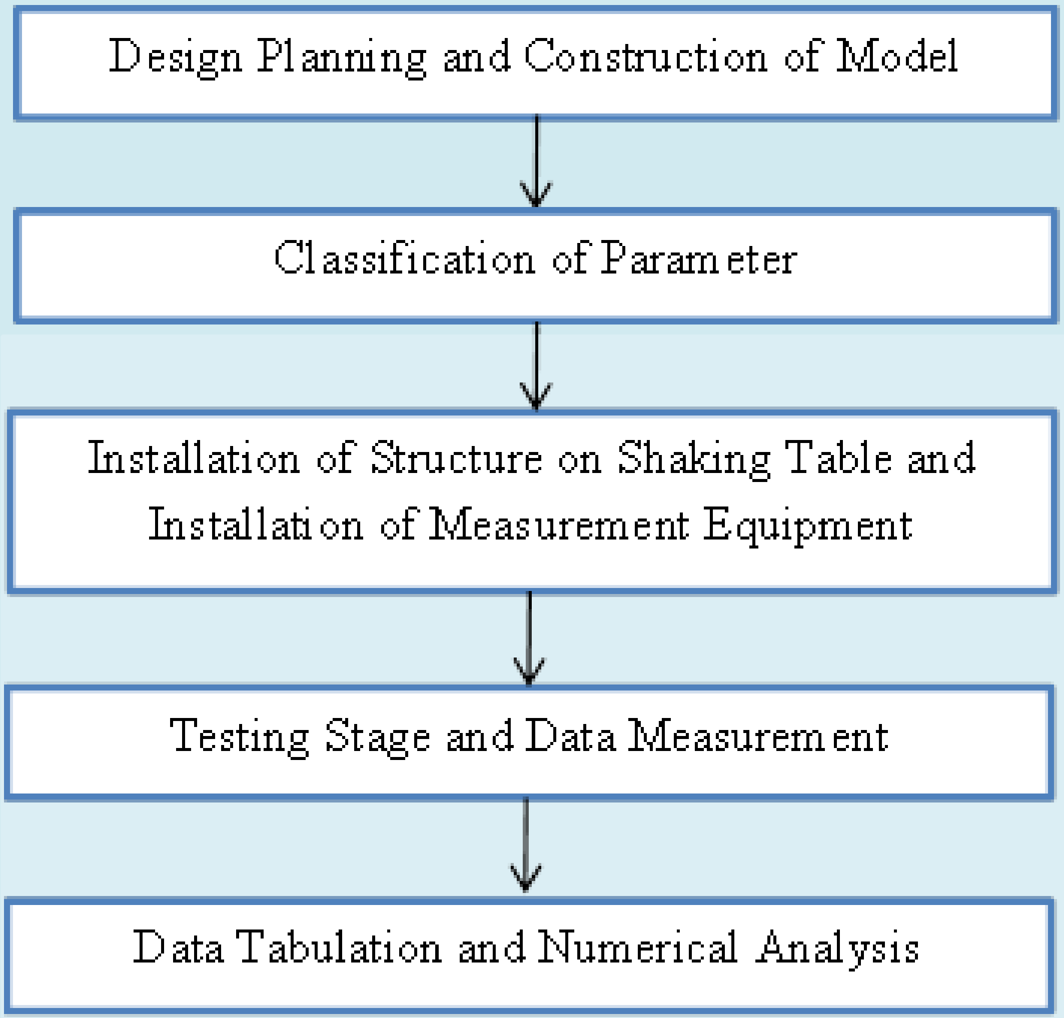
MASS DAMPER

TITLE OF ARTICLE	AUTHORS/YEAR	KEY TOPIC	REMARK
Advances in Structural Engineering	Matsagar (2015)	Mass Damper	• Effectiveness of mass damper is measured in: 1. Displacement 2. Acceleration.
Feasibility Assessment of Levitating Magnetic Damper for Structural Response Control	Razak, et al. (2015)		• Disadvantage of spring: 1. Stiffness can decrease over time. • It is caused by the constant gravitational force

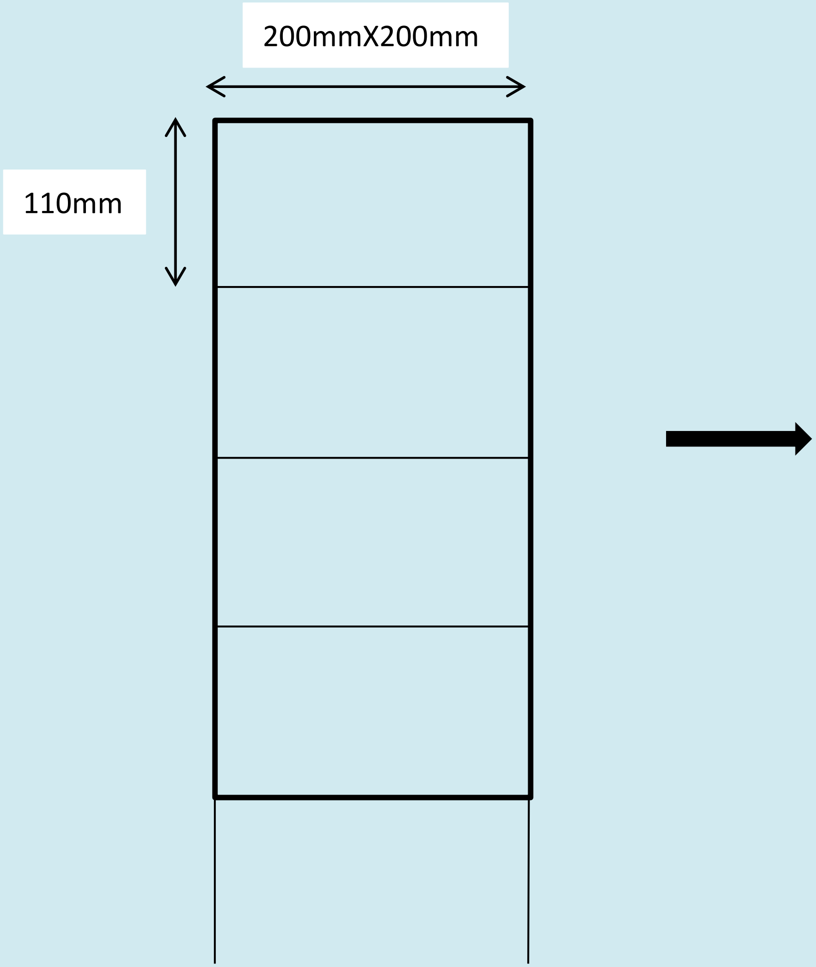
MAGNETIC DAMPER

TITLE OF ARTICLE	AUTHORS/YEAR	KEY TOPIC	REMARK
Results of using permanent magnets to surpress Josephson noise in the KAPPa SIS receiver	Wheeler, et al. (2016)	Magnetic Damper	• replace a tuneable electromagnet with and off-the-shelf fixed permanent magnet system • Disadvantage of electromagnet: 1. too large 2. too much power • permanent magnet does not require any external power supply to function

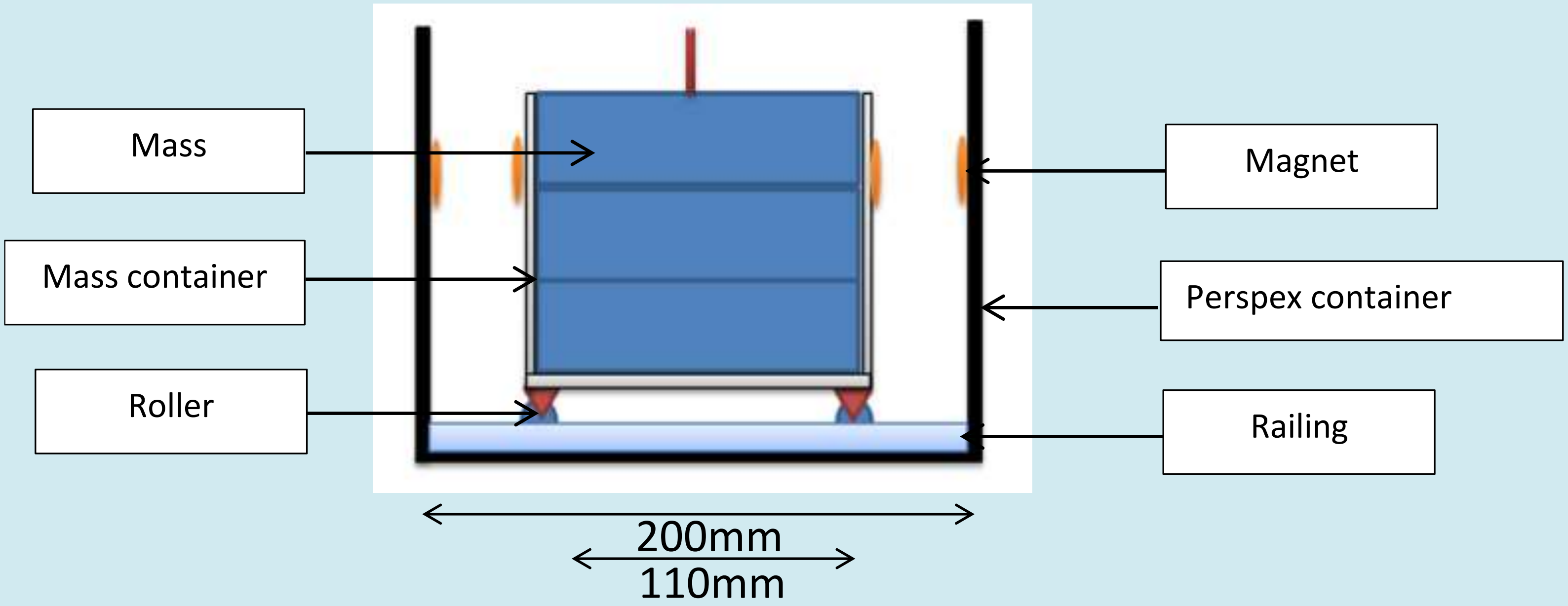
METHODOLOGY

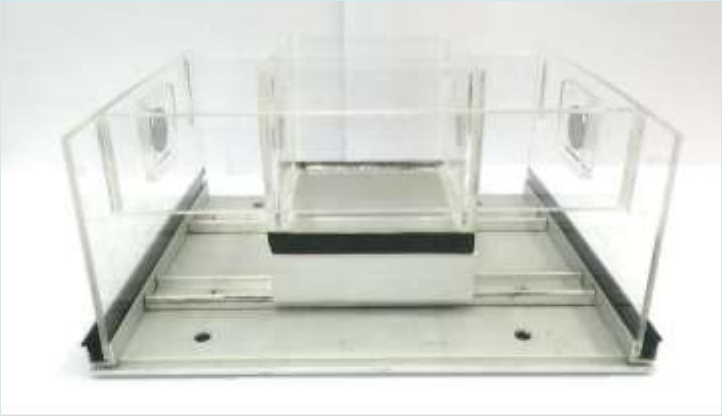

Design Planning and Construction of Model
Classification of Parameter
Installation of Structure on Shaking Table and Installation of Measurement Equipment
Testing Stage and Data Measurement
Data Tabulation and Numerical Analysis

Design of Structure

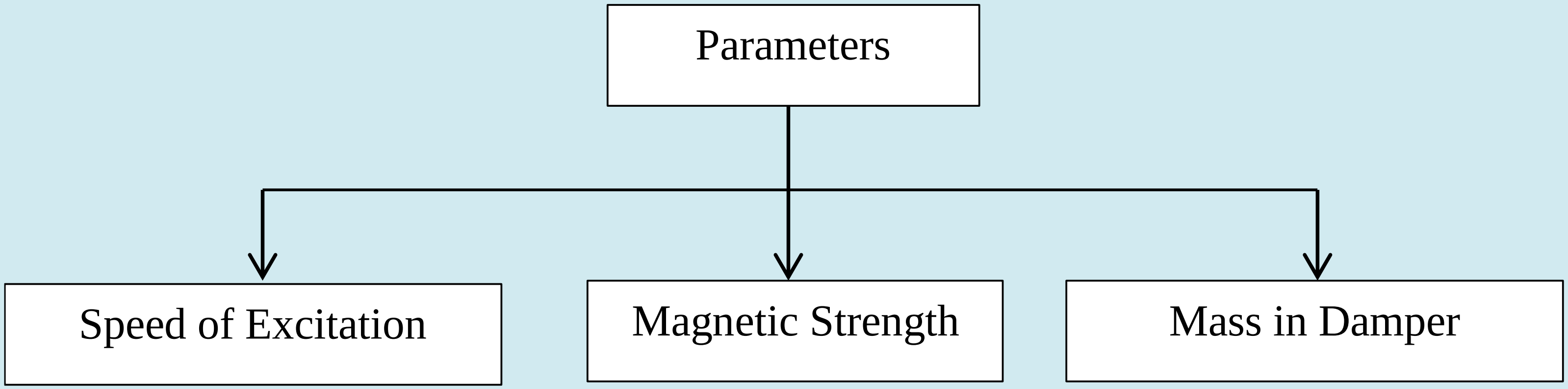


Design of Damper



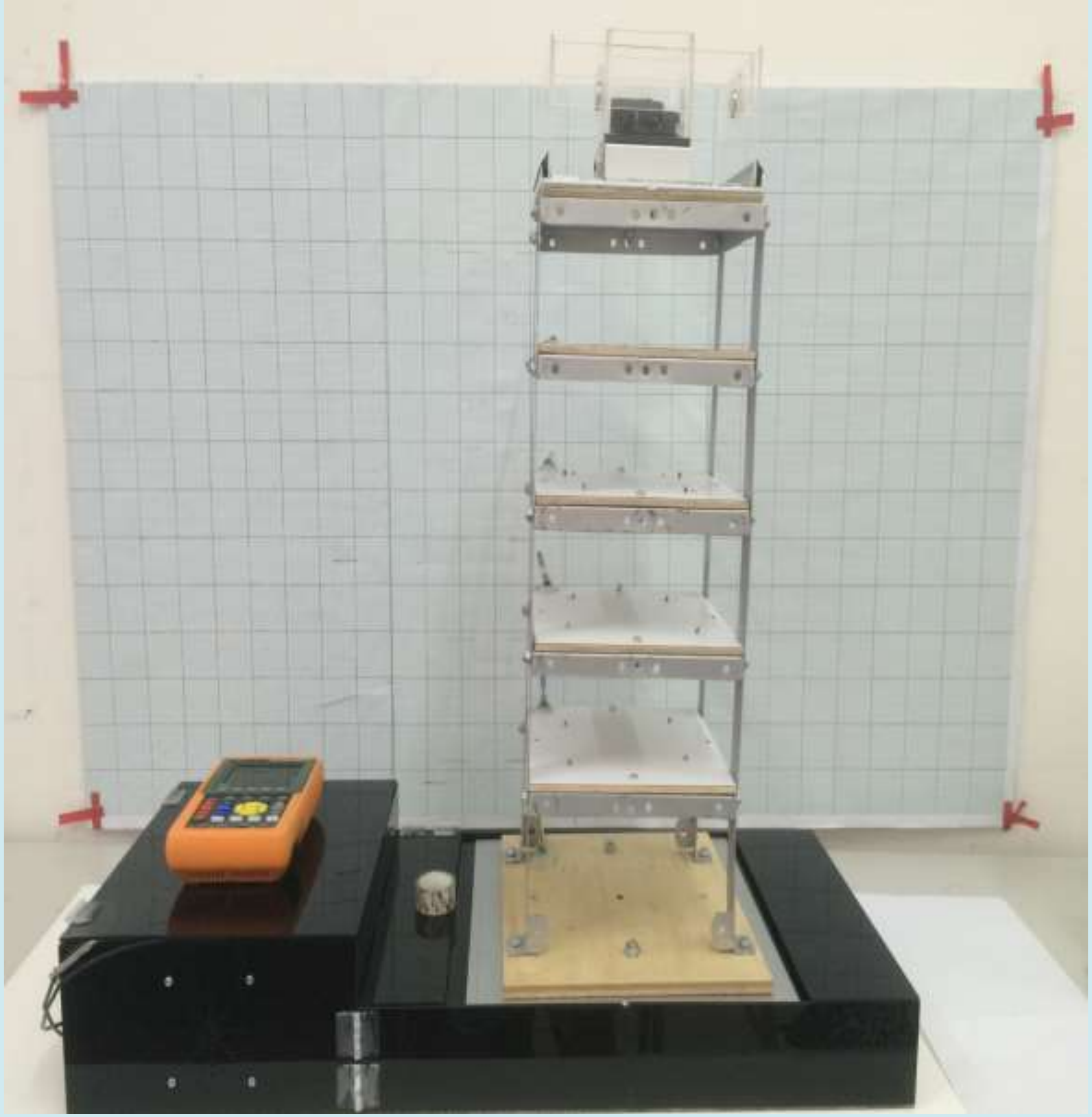


Parameters in the testing



Testing stage

MAGNET STRENGTH	MASS	EXCITATION SPEED
	Mass 1	Low Moderate High
Weak	Mass 2	Low Moderate High
	Mass 3	Low Moderate High
	Mass 1	Low Moderate High
Medium	Mass 2	Low Moderate High
	Mass 3	Low Moderate High
	Mass 1	Low Moderate High
Strong	Mass 2	Low Moderate High
	Mass 3	Low Moderate High



Parameter 1: Excitation Speed

Instrumental Intensity	Acceleration (g)	Velocity (cm/s)	Perceived shaking
I	< 0.0017	< 0.1	Not felt
II–III	0.0017 – 0.014	0.1 – 1.1	Weak
IV	0.014 – 0.039	1.1 – 3.4	Light
V	0.039 – 0.092	3.4 – 8.1	Moderate
VI	0.092 – 0.18	8.1 – 16	Strong

United State of Geological Survey(USGS)

Parameter 2: Magnetic Strength

Material Type	Max. Energy Product (BH)max
N35	33-35 MGOe
N38	36-38 MGOe
N42	40-42 MGOe
N45	43-45 MGOe
N48	45-48 MGOe
N50	48-50 MGOe
N52	49.5-52 MGOe

Parameter 3: Mass in Damper

The mass ratios between 2% and 8% is an appropriate and optimum measure as a control of structural response subjected to seismic ground motions(Lavanya.G & Murad.K, 2015).

Mass of structure: 2020g		
Mass in Damper	Per cent mass ratio (%)	Mass used (g)
M1	2	40
M2	5	101
M3	8	162

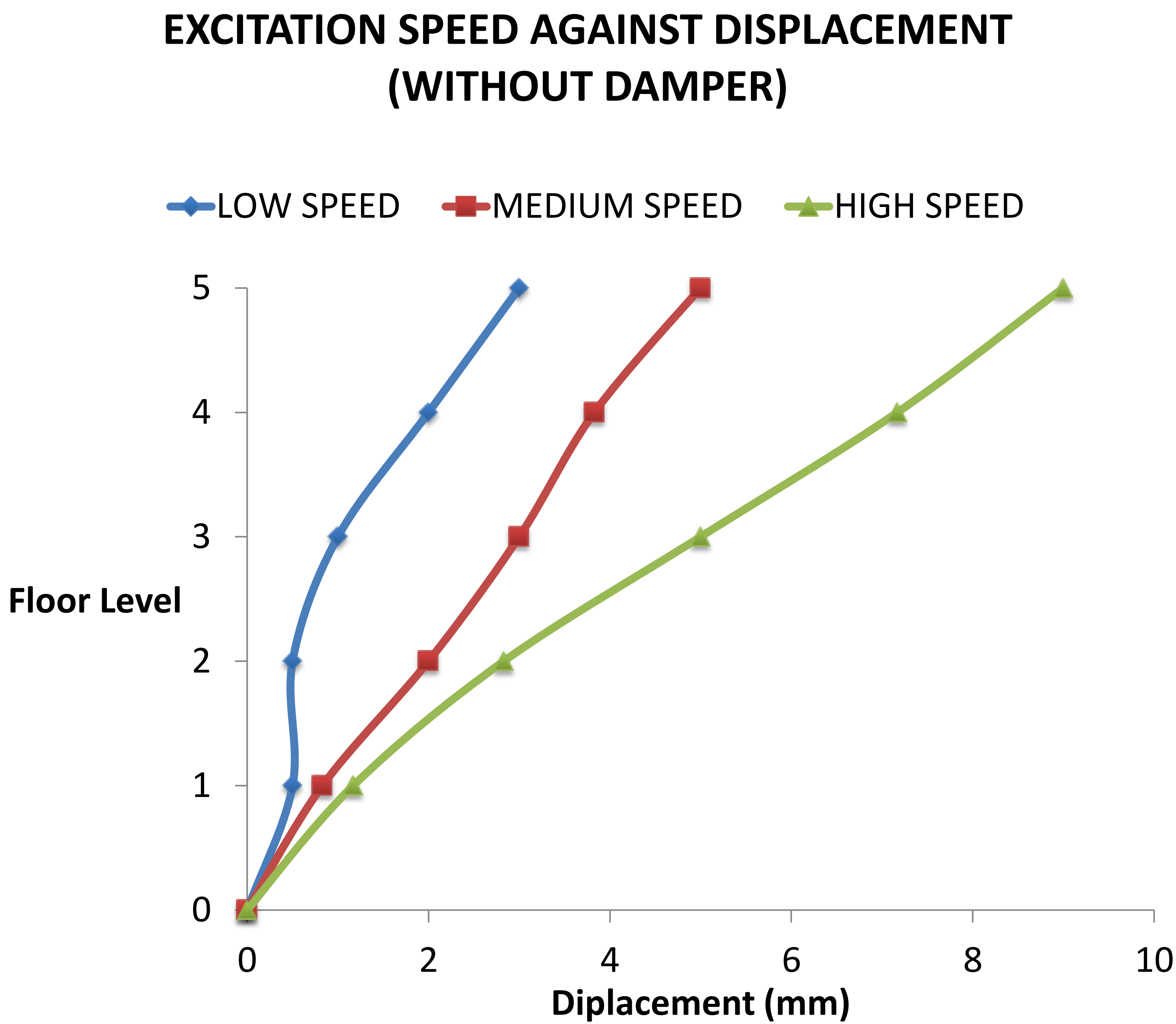
TESTING STAGE



RESULTS & DISCUSSION

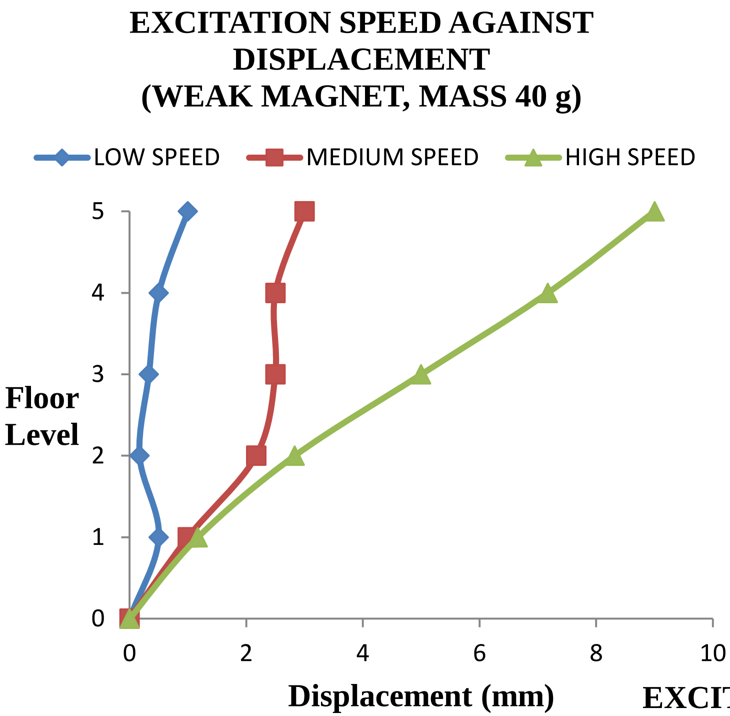
Comprises of 4 parts:

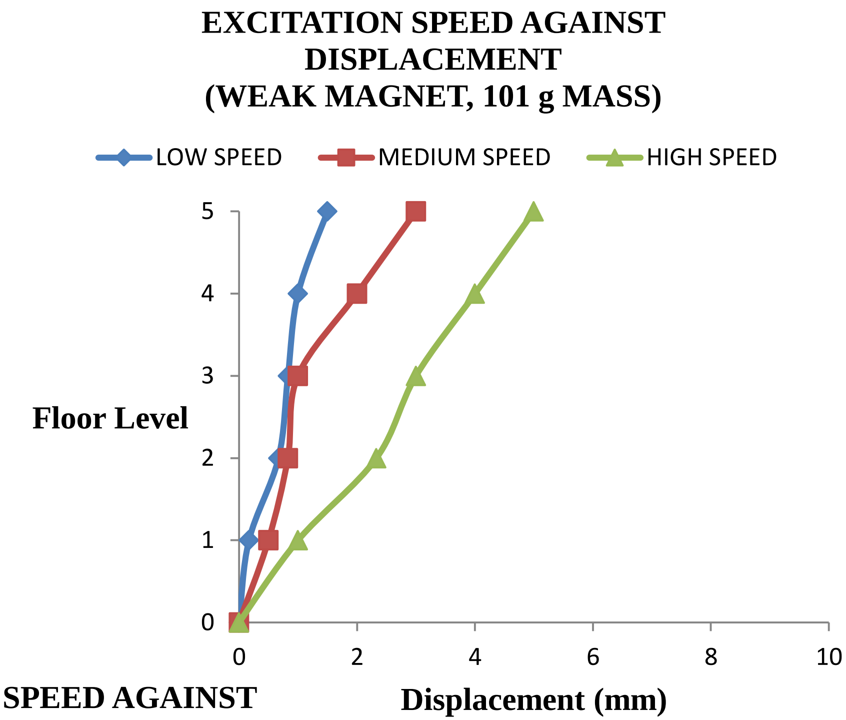
- Preliminary Test **(Control Test- without damper)**
- Comparison of displacement according to different **excitation speed**
- Comparison of displacement according to different **magnetic strength**
- Comparison of displacement according to **masses in damper**

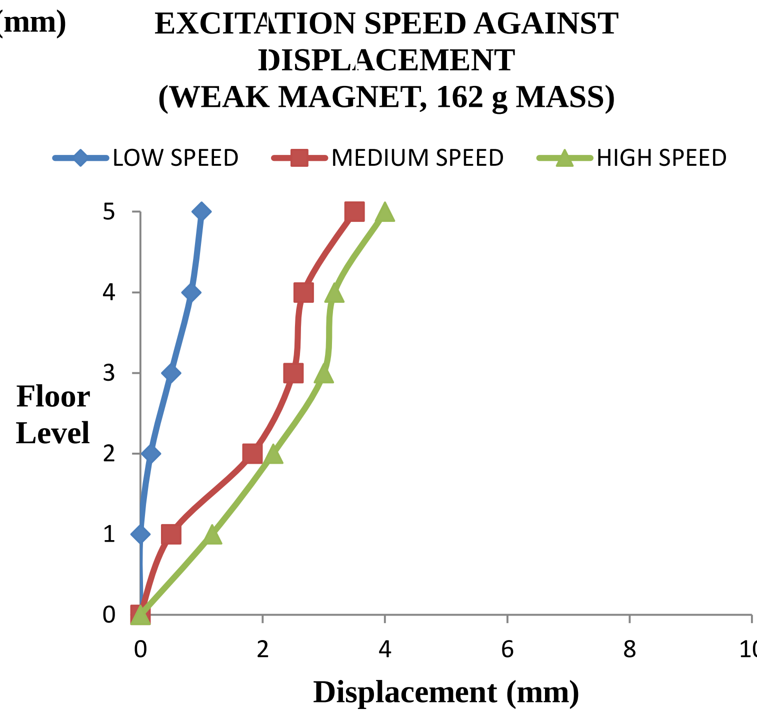


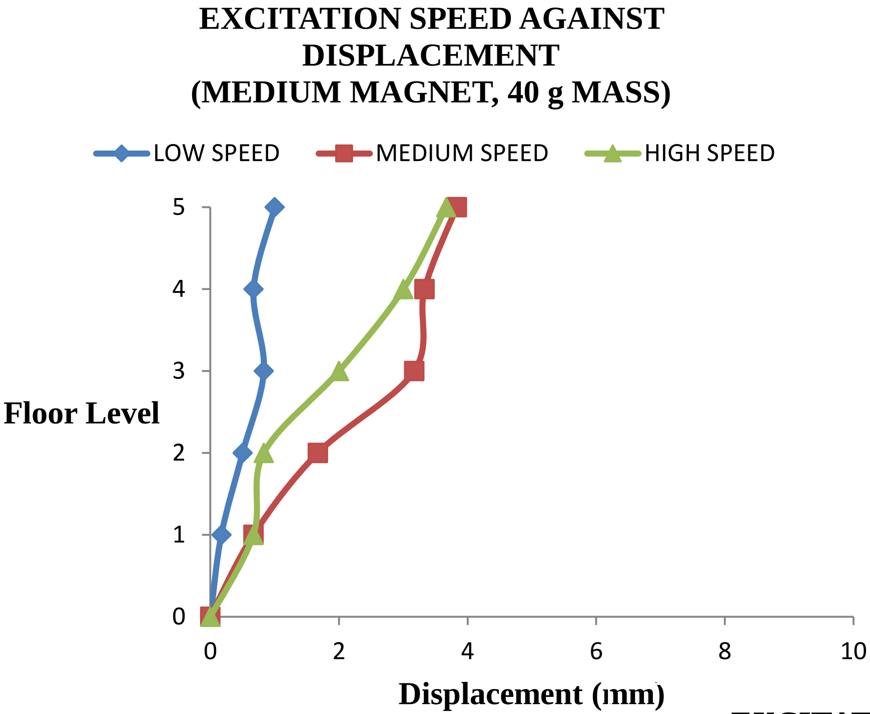
EXCITATION SPEED AGAINST DISPLACEMENT
(WITHOUT DAMPER)
LOW SPEED
MEDIUM SPEED
HIGH SPEED
Floor Level
5
4
3
2
1
0
0
2
4
6
8
10
Diplacement (mm)

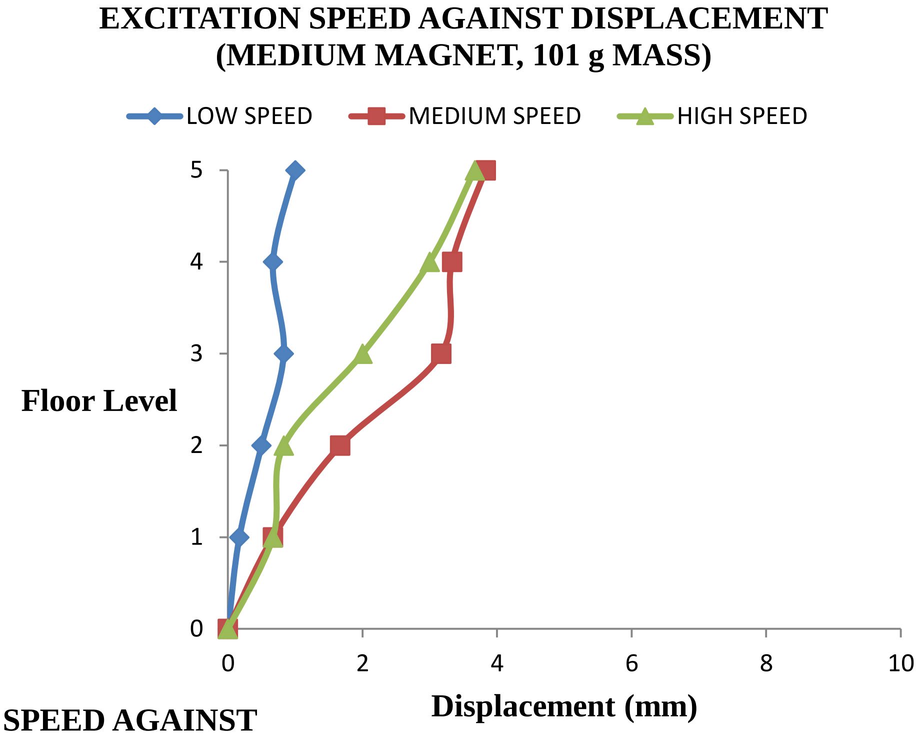
COMPARISON OF DISPLACEMENT WHEN DIFFERENT EXCITATION SPEED WERE APPLIED

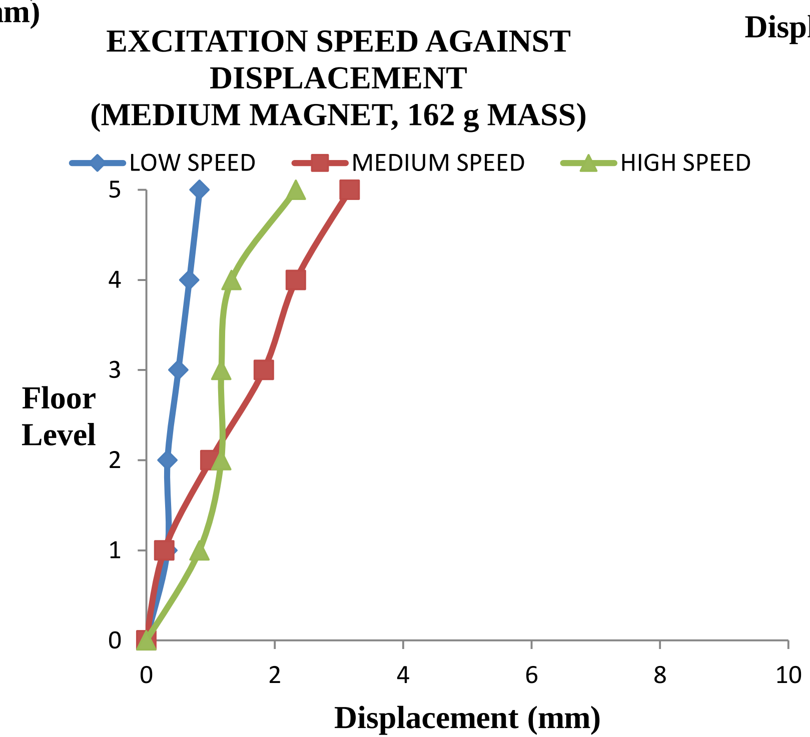

EXCITATION SPEED AGAINST
DISPLACEMENT
(WEAK MAGNET, MASS 40 g)
LOW SPEED
MEDIUM SPEED
HIGH SPEED
Floor Level
0
1
2
3
4
5
0
2
4
6
8
10
Displacement (mm)

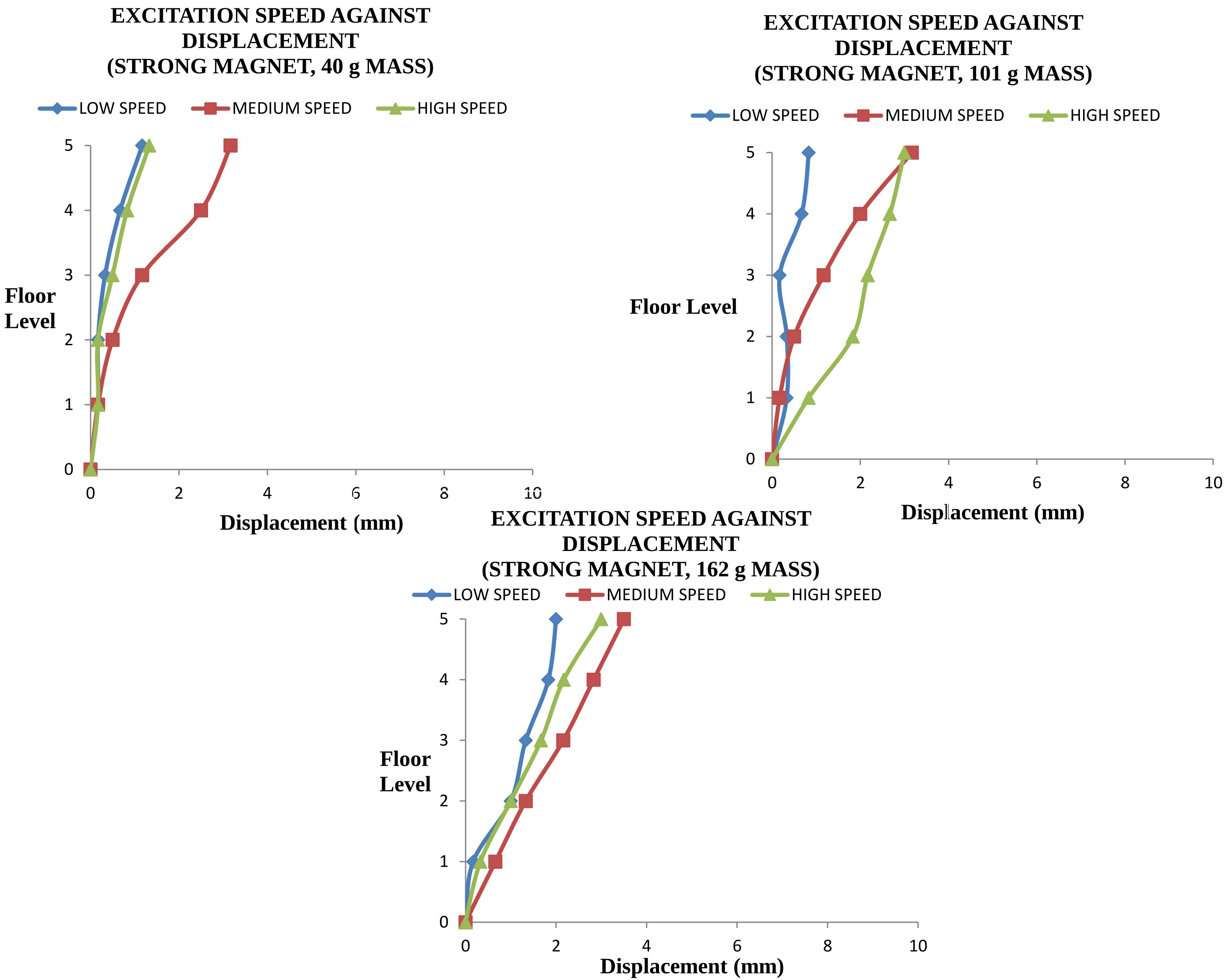

EXCITATION SPEED AGAINST
DISPLACEMENT
(WEAK MAGNET, 101 g MASS)
LOW SPEED
MEDIUM SPEED
HIGH SPEED
Floor Level
0
1
2
3
4
5
0
2
4
6
8
10
Displacement (mm)


EXCITATION SPEED AGAINST
DISPLACEMENT
(WEAK MAGNET, 162 g MASS)
LOW SPEED
MEDIUM SPEED
HIGH SPEED
Floor Level
0
1
2
3
4
5
0
2
4
6
8
10
Displacement (mm)


EXCITATION SPEED AGAINST DISPLACEMENT
(MEDIUM MAGNET, 40 g MASS)
LOW SPEED
MEDIUM SPEED
HIGH SPEED
Floor Level
0
1
2
3
4
5
0
2
4
6
8
10
Displacement (mm)


EXCITATION SPEED AGAINST DISPLACEMENT
(MEDIUM MAGNET, 101 g MASS)
LOW SPEED
MEDIUM SPEED
HIGH SPEED
Floor Level
0
1
2
3
4
5
0
2
4
6
8
10
Displacement (mm)

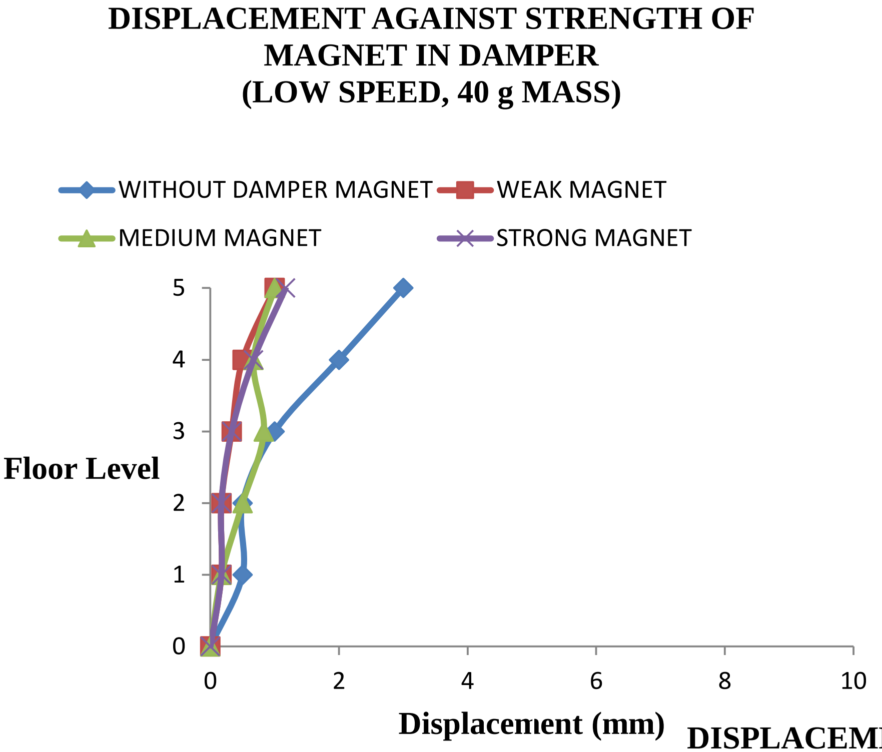

EXCITATION SPEED AGAINST DISPLACEMENT
(MEDIUM MAGNET, 162 g MASS)
LOW SPEED
MEDIUM SPEED
HIGH SPEED
Floor Level
0
1
2
3
4
5
0
2
4
6
8
10
Displacement (mm)

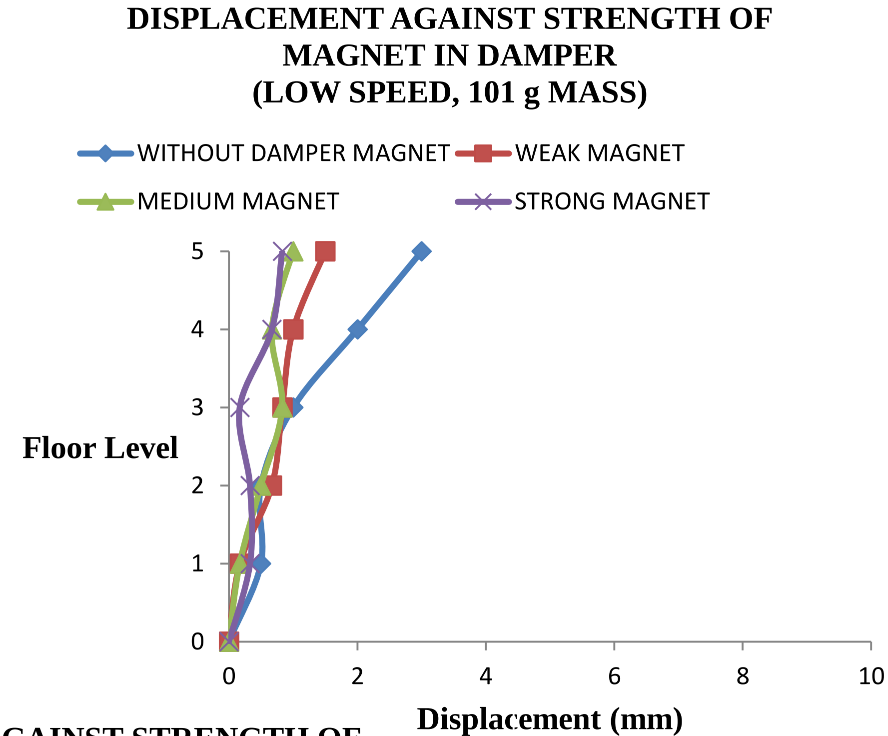

EXCITATION SPEED AGAINST DISPLACEMENT
(STRONG MAGNET, 40 g MASS)
LOW SPEED
MEDIUM SPEED
HIGH SPEED
Floor Level
0
1
2
3
4
5
0
2
4
6
8
10
Displacement (mm)
EXCITATION SPEED AGAINST DISPLACEMENT
(STRONG MAGNET, 101 g MASS)
LOW SPEED
MEDIUM SPEED
HIGH SPEED
Floor Level
0
1
2
3
4
5
0
2
4
6
8
10
Displacement (mm)
EXCITATION SPEED AGAINST DISPLACEMENT
(STRONG MAGNET, 162 g MASS)
LOW SPEED
MEDIUM SPEED
HIGH SPEED
Floor Level
0
1
2
3
4
5
0
2
4
6
8
10
Displacement (mm)

SUMMARY

OPTIMUM DAMPER
• Damper when applied with high excitation speed (8.5V) • Reduction of displacement- up to 55.8%

COMPARISON OF DISPLACEMENT WHEN DIFFERENT STRENGTH OF MAGNETS WERE APPLIED


DISPLACEMENT AGAINST STRENGTH OF MAGNET IN DAMPER
(LOW SPEED, 40 g MASS)
WITHOUT DAMPER MAGNET
WEAK MAGNET
MEDIUM MAGNET
STRONG MAGNET
Floor Level
Displacement (mm)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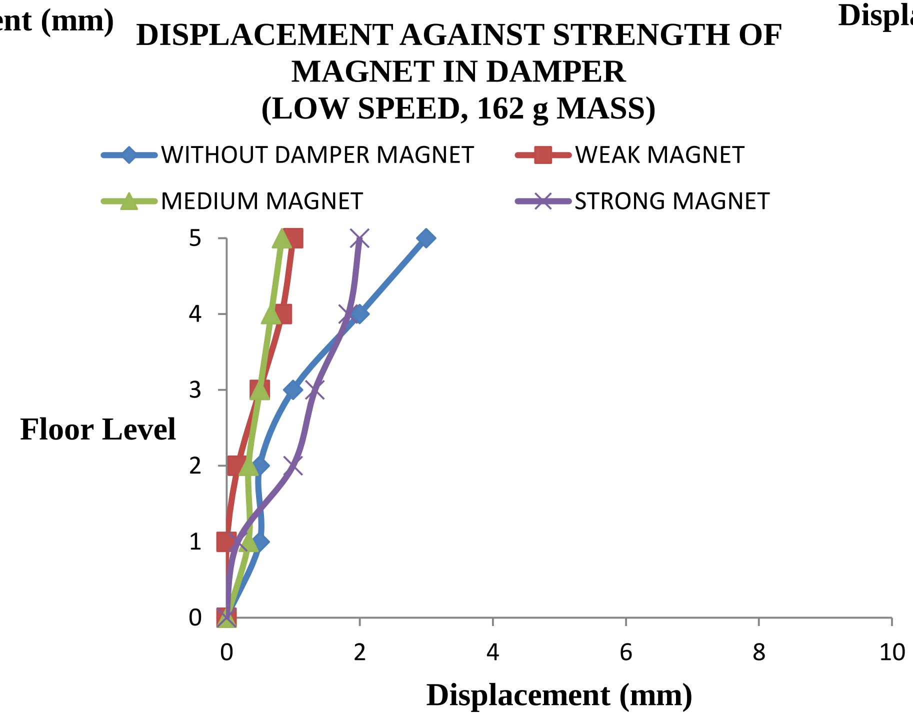
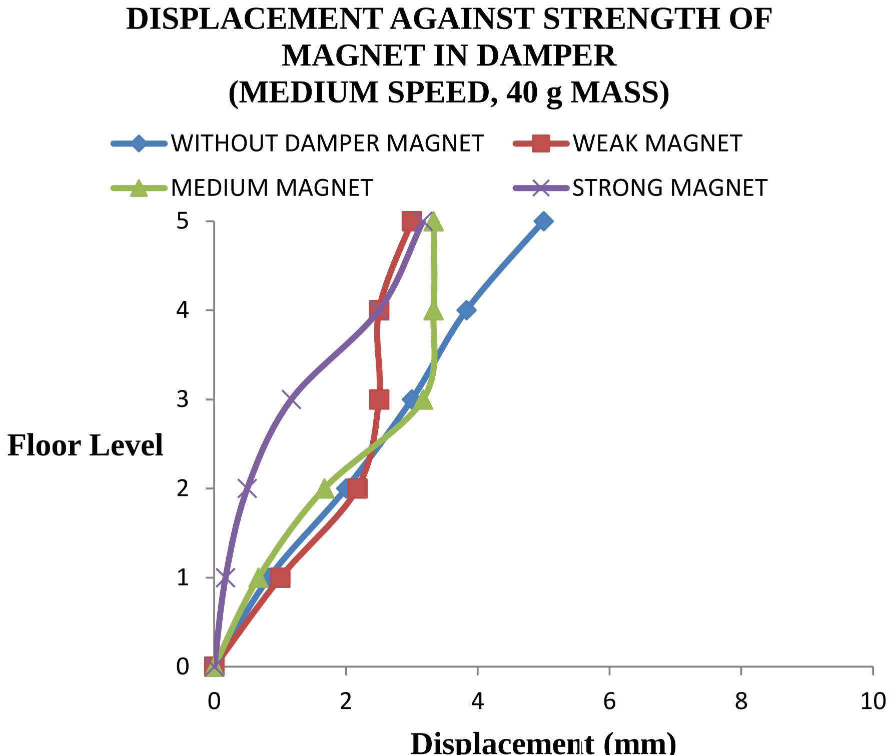
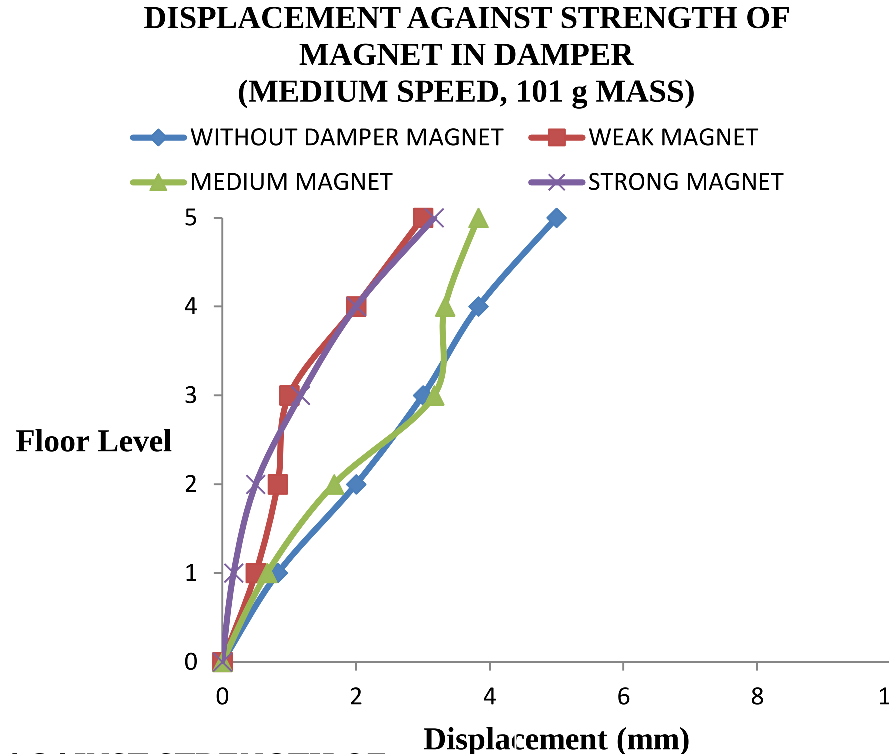
(LOW SPEED, 101 g MASS)
WITHOUT DAMPER MAGNET
WEAK MAGNET
MEDIUM MAGNET
STRONG MAGNET
Floor Level
Displacement (mm)


DISPLACEMENT AGAINST STRENGTH OF MAGNET IN DAMPER
(LOW SPEED, 162 g MASS)
WITHOUT DAMPER MAGNET
WEAK MAGNET
MEDIUM MAGNET
STRONG MAGNET
Floor Level
Displacement (mm)


DISPLACEMENT AGAINST STRENGTH OF MAGNET IN DAMPER
(MEDIUM SPEED, 40 g MASS)
WITHOUT DAMPER MAGNET
WEAK MAGNET
MEDIUM MAGNET
STRONG MAGNET
Floor Level
0
1
2
3
4
5
0
2
4
6
8
10
Displacement (mm)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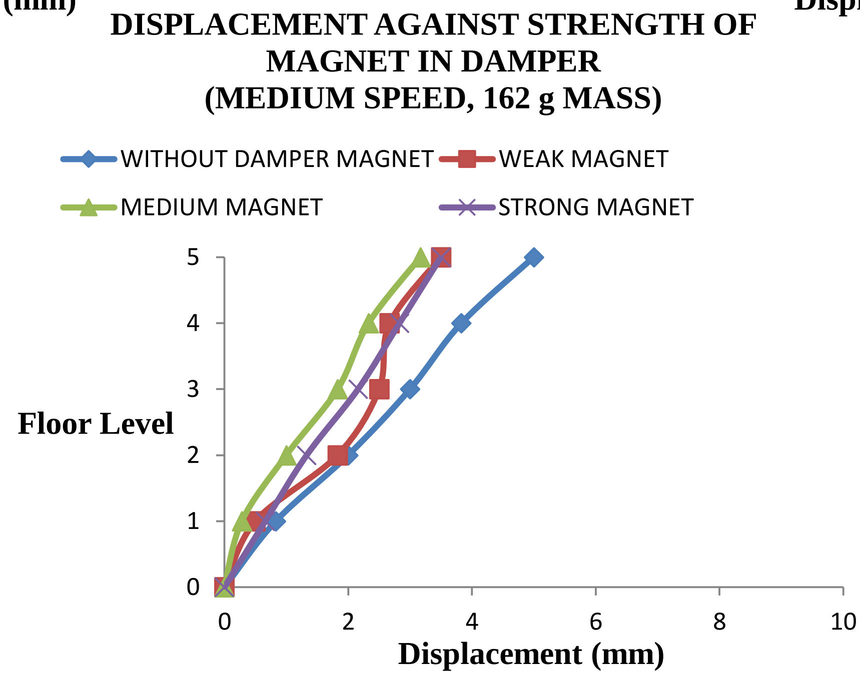
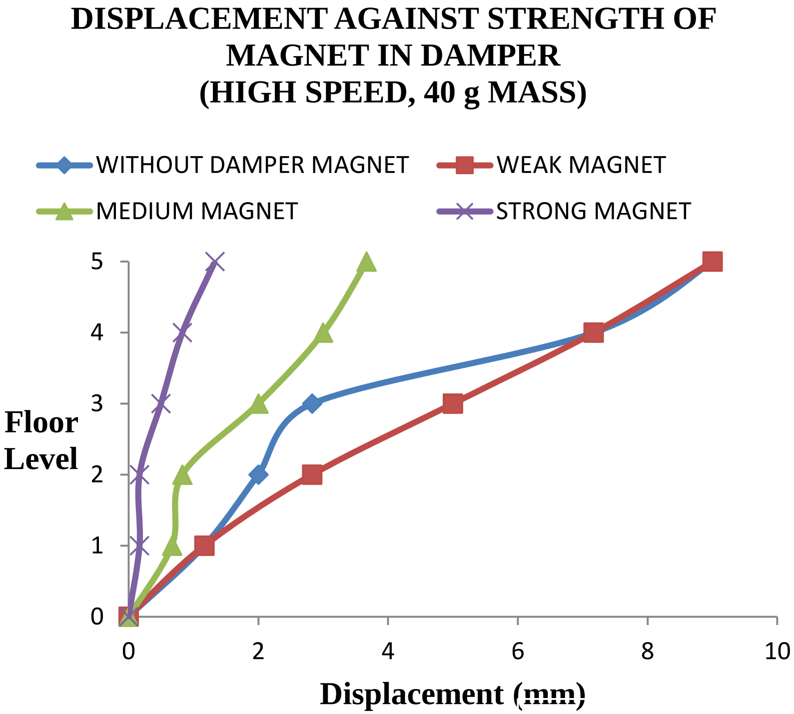
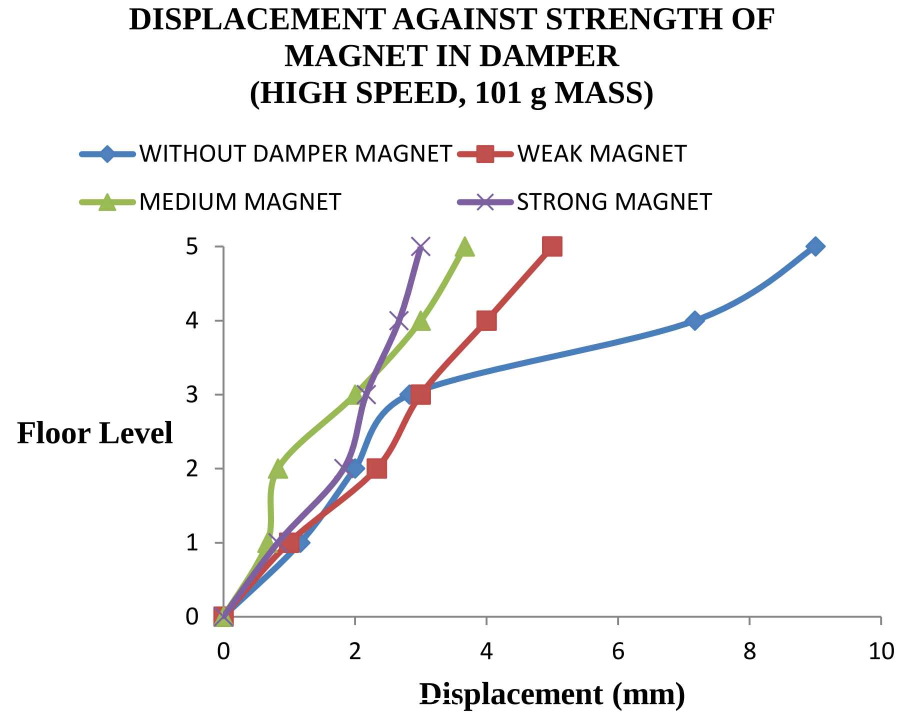
(MEDIUM SPEED, 101 g MASS)
WITHOUT DAMPER MAGNET
WEAK MAGNET
MEDIUM MAGNET
STRONG MAGNET
Floor Level
0
1
2
3
4
5
0
2
4
6
8
10
Displacement (mm)


DISPLACEMENT AGAINST STRENGTH OF MAGNET IN DAMPER
(MEDIUM SPEED, 162 g MASS)
WITHOUT DAMPER MAGNET
WEAK MAGNET
MEDIUM MAGNET
STRONG MAGNET
Floor Level
0
1
2
3
4
5
0
2
4
6
8
10
Displacement (mm)


DISPLACEMENT AGAINST STRENGTH OF MAGNET IN DAMPER
(HIGH SPEED, 40 g MASS)
WITHOUT DAMPER MAGNET
WEAK MAGNET
MEDIUM MAGNET
STRONG MAGNET
Floor Level
0
1
2
3
4
5
0
2
4
6
8
10
Displacement (mm)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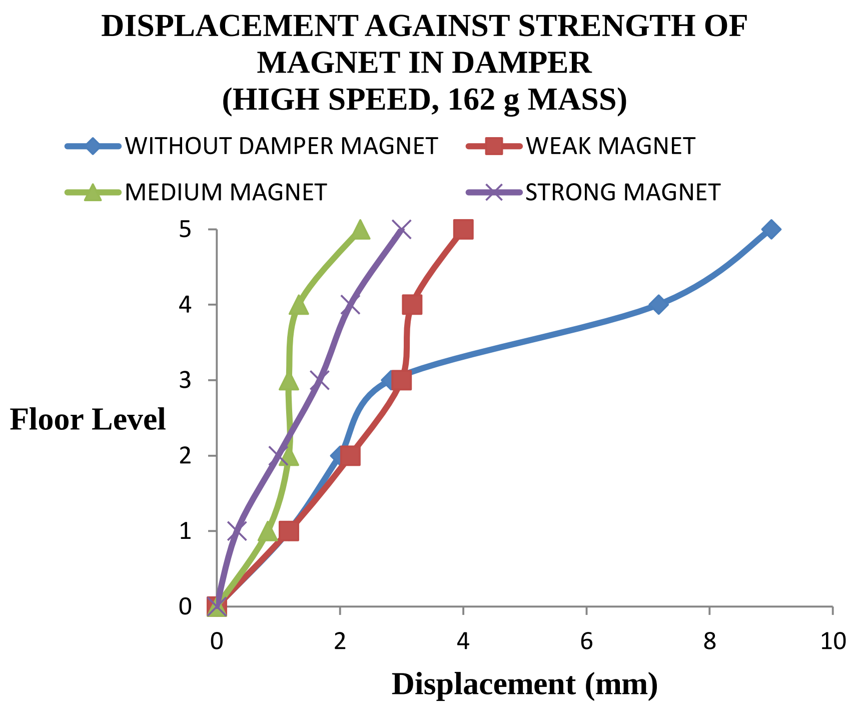
WITHOUT DAMPER MAGNET
WEAK MAGNET
MEDIUM MAGNET
STRONG MAGNET
Floor Level
0
1
2
3
4
5
0
2
4
6
8
10
Displacement (mm)

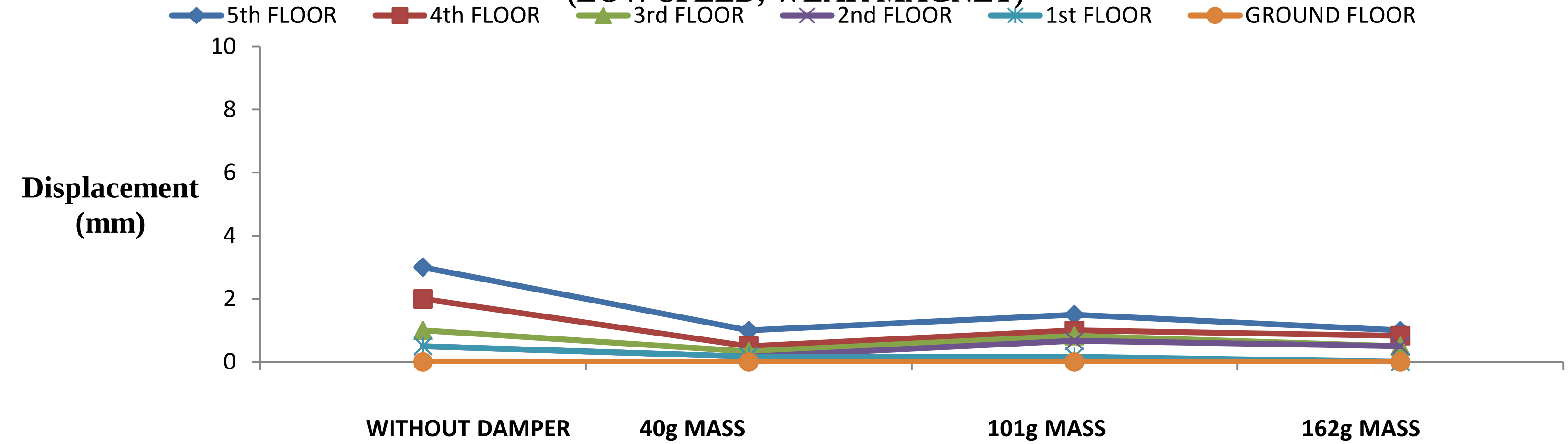

DISPLACEMENT AGAINST STRENGTH OF MAGNET IN DAMPER
(HIGH SPEED, 162 g MASS)
WITHOUT DAMPER MAGNET
WEAK MAGNET
MEDIUM MAGNET
STRONG MAGNET
Floor Level
0
1
2
3
4
5
0
2
4
6
8
10
Displacement (mm)

SUMMARY

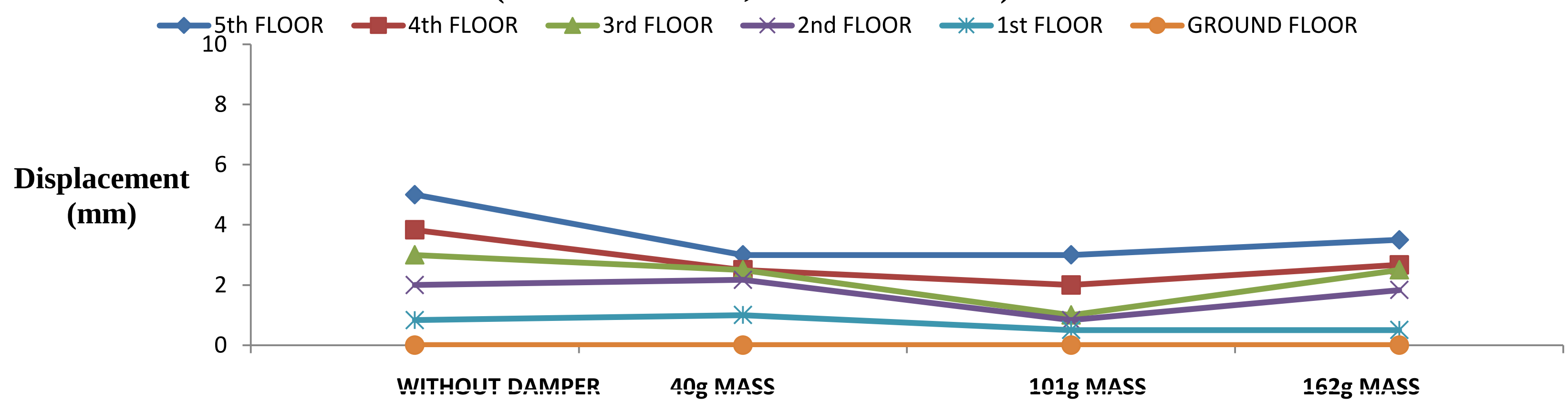
OPTIMUM DAMPER
• Damper with strong magnet • Reduction of displacement- up to 94%

COMPARISON OF DISPLACEMENT WHEN DIFFERENT MASSES WERE APPLIED IN THE DAMPER

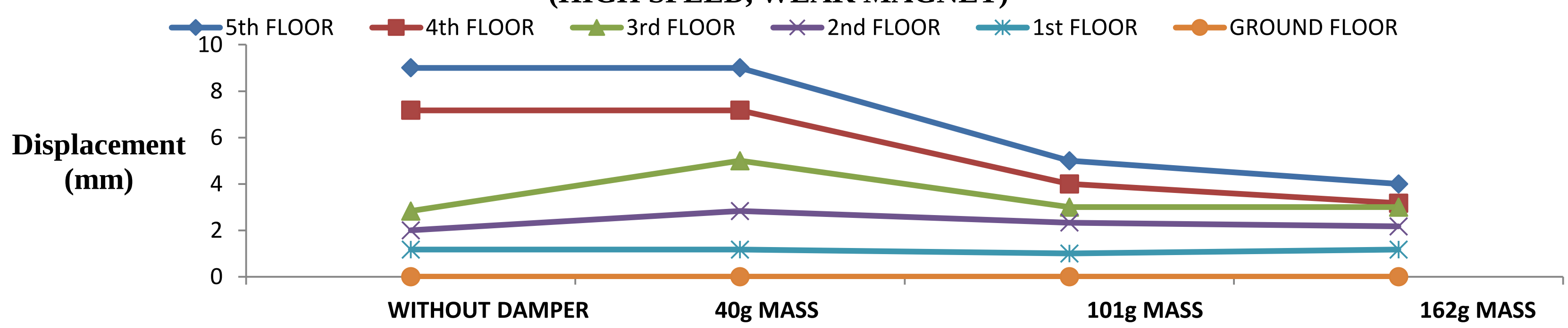
DISPLACEMENT AGAINST MASS IN DAMPER (LOW SPEED, WEAK MAGNET)

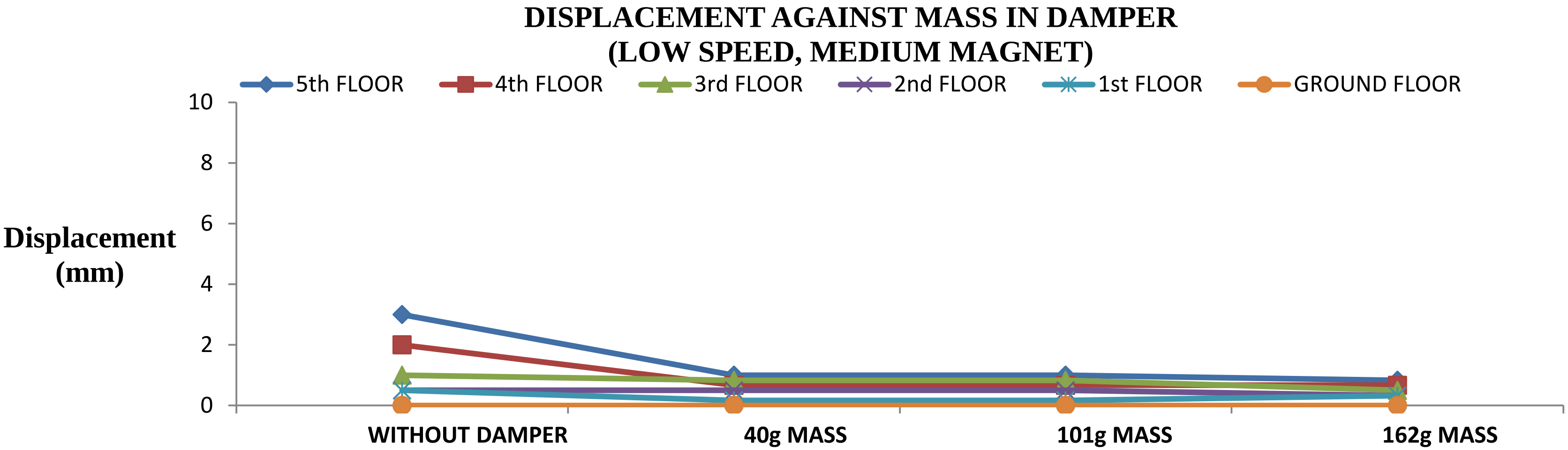


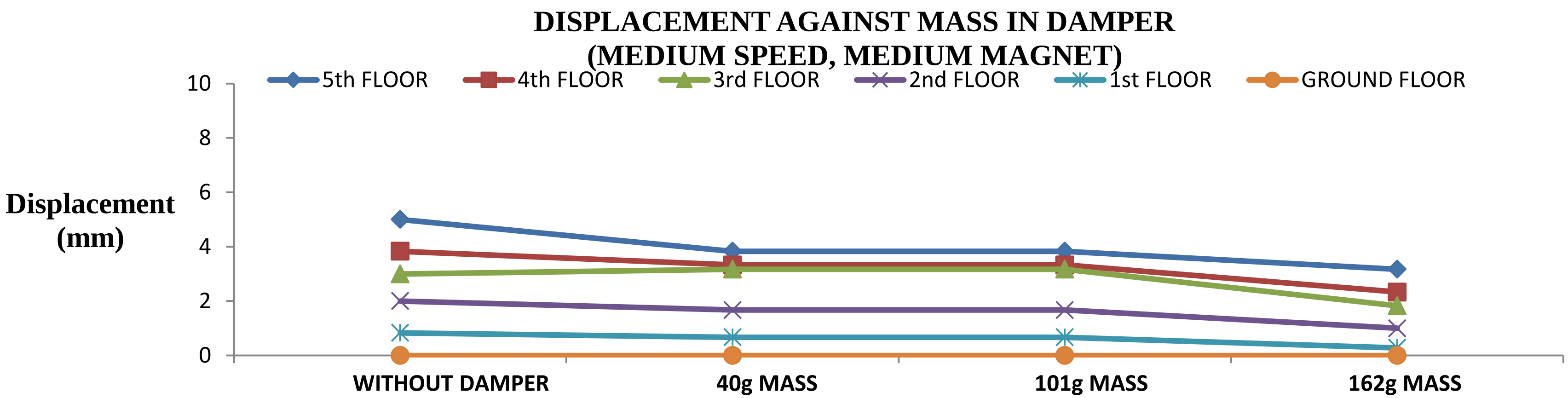
DISPLACEMENT AGAINST MASS IN DAMPER (MEDIUM SPEED, WEAK MAGNET)

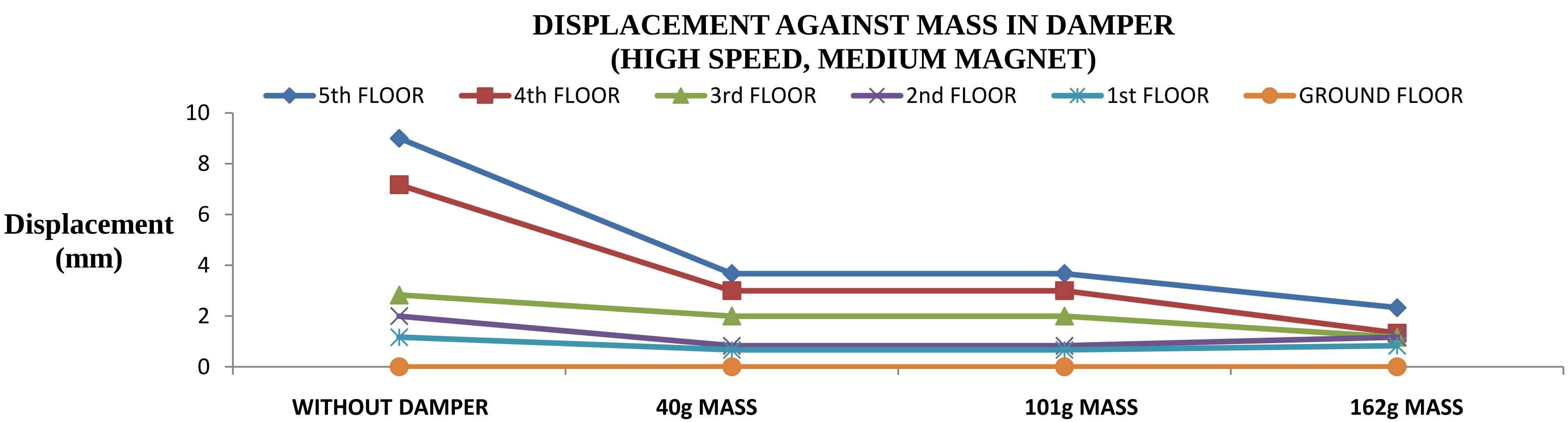


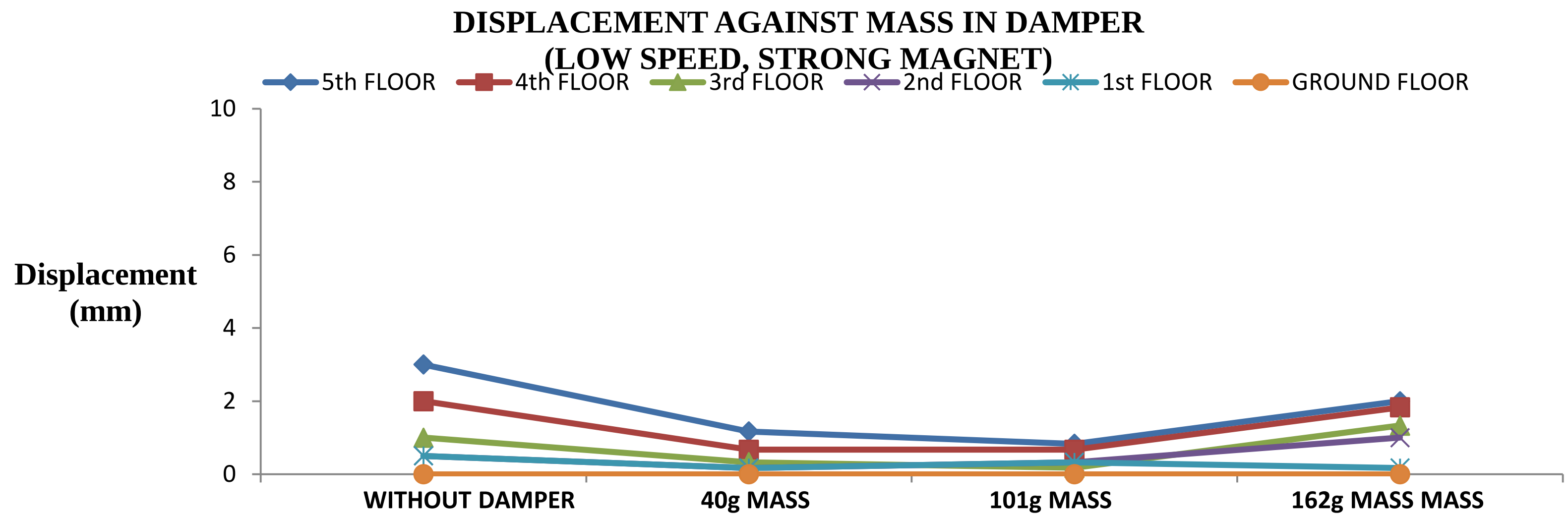
DISPLACEMENT AGAINST MASS IN DAMPER (HIGH SPEED, WEAK MAGNET)

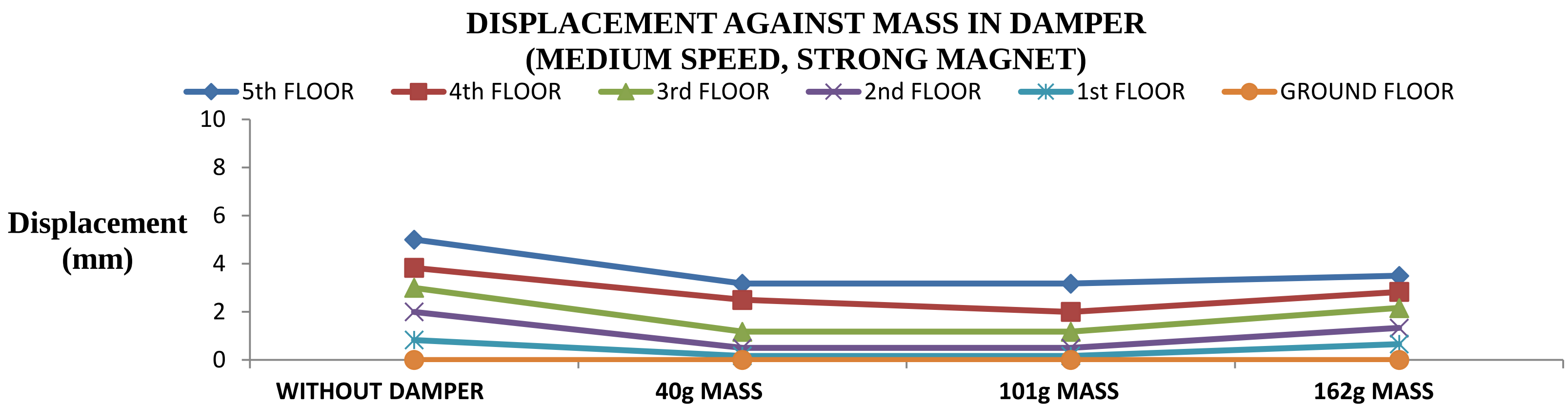


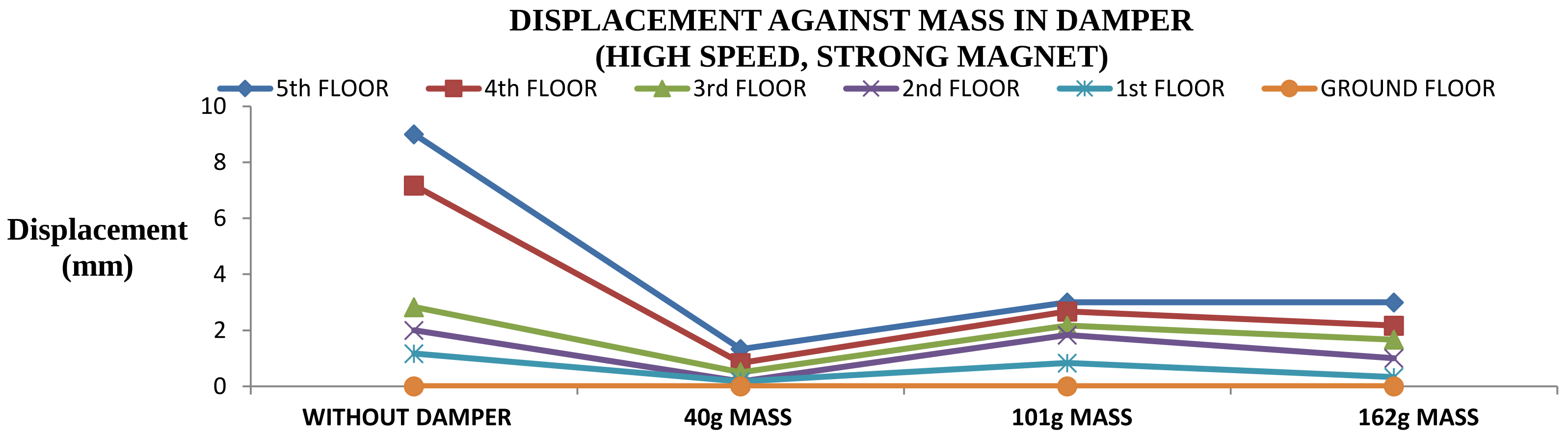

DISPLACEMENT AGAINST MASS IN DAMPER
(LOW SPEED, MEDIUM MAGNET)
5th FLOOR
4th FLOOR
3rd FLOOR
2nd FLOOR
1st FLOOR
GROUND FLOOR
Displacement (mm)
0
2
4
6
8
10
WITHOUT DAMPER
40g MASS
101g MASS
162g MASS


DISPLACEMENT AGAINST MASS IN DAMPER
(MEDIUM SPEED, MEDIUM MAGNET)
5th FLOOR
4th FLOOR
3rd FLOOR
2nd FLOOR
1st FLOOR
GROUND FLOOR
Displacement (mm)
0
2
4
6
8
10
WITHOUT DAMPER
40g MASS
101g MASS
162g MASS


DISPLACEMENT AGAINST MASS IN DAMPER
(HIGH SPEED, MEDIUM MAGNET)
5th FLOOR
4th FLOOR
3rd FLOOR
2nd FLOOR
1st FLOOR
GROUND FLOOR
Displacement (mm)
0
2
4
6
8
10
WITHOUT DAMPER
40g MASS
101g MASS
162g MASS


DISPLACEMENT AGAINST MASS IN DAMPER
(LOW SPEED, STRONG MAGNET)
5th FLOOR
4th FLOOR
3rd FLOOR
2nd FLOOR
1st FLOOR
GROUND FLOOR
Displacement (mm)
10
8
6
4
2
0
WITHOUT DAMPER
40g MASS
101g MASS
162g MASS MASS


DISPLACEMENT AGAINST MASS IN DAMPER
(MEDIUM SPEED, STRONG MAGNET)
5th FLOOR
4th FLOOR
3rd FLOOR
2nd FLOOR
1st FLOOR
GROUND FLOOR
Displacement (mm)
10
8
6
4
2
0
WITHOUT DAMPER
40g MASS
101g MASS
162g MASS


DISPLACEMENT AGAINST MASS IN DAMPER
(HIGH SPEED, STRONG MAGNET)
5th FLOOR
4th FLOOR
3rd FLOOR
2nd FLOOR
1st FLOOR
GROUND FLOOR
Displacement (mm)
10
8
6
4
2
0
WITHOUT DAMPER
40g MASS
101g MASS
162g MASS

SUMMARY

OPTIMUM DAMPER
• Damper with 162 g masses • Reduction of displacement- up to 81.5%

CONCLUSION

- As a conclusion, the most optimum magnetic mass damper is by using the strong magnetic strength containing 162 g mass.

- When tested with three speed of excitation; 2.5V 6.0V and 8.5V, the damper provide the most optimum damping effect towards the structural displacement.

CONTRIBUTIONS

THANK YOU ..