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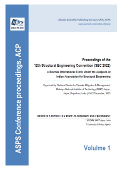

Blast Mitigation of SDOF systems by using M.R.Damper and Base Isolations

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Abstract

Shelter is a basic need for living creatures. The shelter should be safe and secure. The damage of the shelter occurs due to natural hazards and manmade activities. Natural hazards such as earthquake, volcanic eruptions, landslides, flood, etc. Manmade activities may be accidental or intentional. Accidental activities include, internal explosions such as chemical reactions occurring at nuclear power plants, mining, rock cutting etc, gas explosions leakage etc. Hence while designing the structure, additional precautions and considerations should be taken to resist the unpredictable load. Boat load and earthquake load are dynamic, impulse loads. The earthquake load occurs in seconds, In the height of the structures force are distributed and is proportion to mass concentrations, blast load occurs in milli seconds compare to seismic load. In the present study SDOF system exposed to blast load is considered. MATLAB simulation technique is used in the analysis of the SDOF system. The SDOF system consists of Front wall, rear wall and Roof. The load is acting on the structural system are calculated by using analytical method. Base isolations method is one the recent method is used to reduce the response of the structural system under impact load. The semi active control system is used in the analysis. The response is reduced by considerable amount by using Base isolation and MR Damper.

Keywords: Blast load, Base isolation with LRB, M.R. Damper, SDOF system

1. Introduction

The mathematical modelling and practical applications of the structural system exposed to blast load is presented. Structure above the ground surface, exposed to blast load with dynamic effects on unconfined blast load is considered [1]. The basic requirements of blast load, the blast load phenomenon and design principals of blast load. Structure responses due to blast load, includes the pressure impulse curve, elastic SDOF, energy solutions of SDOF. It includes the design strength and design parameters used in steel members, health and safety measurements, risk assessment and future considerations [2].The history of introduction of explosive of blast load in the world source, dynamic properties of the structure which includes the SDOF, 2DOF and MDOF system, basic concepts of sonic booms, explosive occurring in different materials that is explosive in air, explosive in air, explosive in water, explosive in soil and nonlinear finite element analysis of structure [3].

The applications of the pressure impulse curve in practical. The damage criteria of the houses built by the brick, office building and light framed building can be obtained by pressure impulse curve. The damage criteria of the human organs like eardrum, lungs etc are obtained by pressure impulse curve [4]. The importance of SDOF system exposed to blast load, analytical procedure of plotting the pressure impulse curve for SDOF system is stated. The characteristics of pressure impulse curve, the maximum deflection damage criteria is based on PI curve, pulse load shape factors of the pressure impulse curve is mentioned [5 &6].

Multi storey structure exposed to seismic force controlled by base isolations system with the effect of adjacent structure. The differential equations are derived by using the method of Newmark's step by step. Differences of the parameter such as stiffness, number of floors, super structure flexibility, size of the gap of the stiffness is studied. The bearing displacement decreases with increases in accelerations of the super structure with adjacent structures is considered. presented the response of multi storey structure by seismic forces controlled by isolators. The two different models are chosen, mathematical model of bi linear and hysteretic and mathematical model is equivalent linear elastic viscous behaviours. Different bilinear models of hysteretic and its equivalent model obtained the comparisons of base isolated flexible building. The parameters of yield displacement and force on the effective isolations systems influence the shape of isolators of hysteresis loops [7 &8]. presented the seismic performance of a nuclear power plant to analyse lead rubber bearing system and the nonlinear behaviour of the power plant. The applications of base isolation system is used in many field. The base isolations behaviour is analysed under normal conditions and studied by many literatures. In this work base isolations system under extreme conditions, its behaviour is studied. The numerical test shows that nuclear

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power plants under extreme conditions exhibits its better performance [9].

Low damping isolations bearings and MR damper fluids of a base isolated building. Magnetic field properties change its fluid properties & results in MR damper in magnetic field. Advantage of MR damper is cost effective and optimal control under change in excitation of magnetic field. Two model of five and eight storey structures controlled by MR damper exposed to seismic forces [10].

The Present study consists of the following parameters

(i) The load acting on the Front wall, Rear wall and Roof (ii) The response is reduced to SDOF system by using Base isolation with Lead Rubber Bearing (LRB) system (iii) The response is reduced to SDOF system by using M.R.Damper and (iv) Increase of the pressure impulse diagram by using Base isolation and M.R.Damper will not cause damage to the structural system.

2. Structural Models

2.1. SDOF system

Fig.1. represents the SDOF system subjected to blast load. It contains the blast load acting at a distance range from SDOF system and it contains front wall, rear wall.

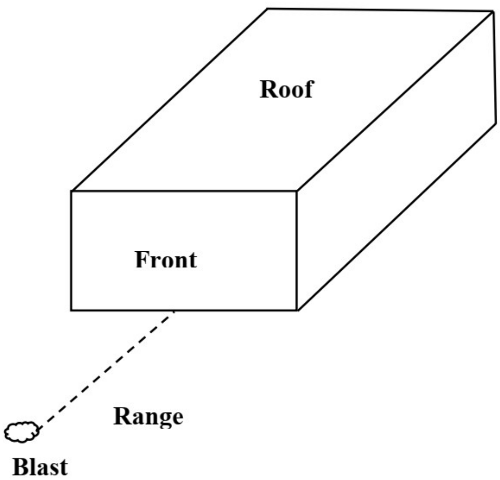

Figure.1. Structural System exposed to blast load

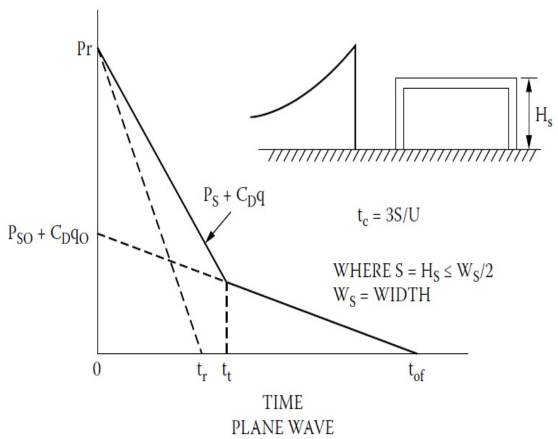

Figure.2. Front-wall loading

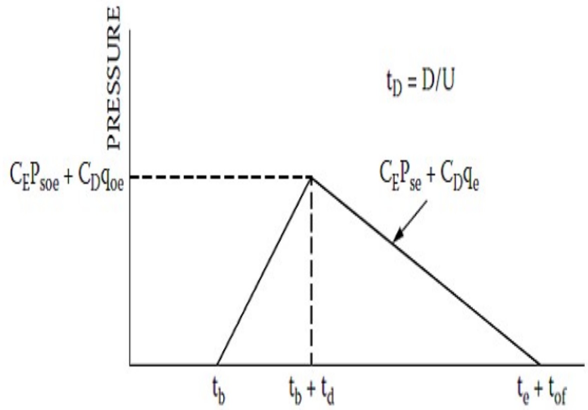

Figure.3. Rear-walls loading

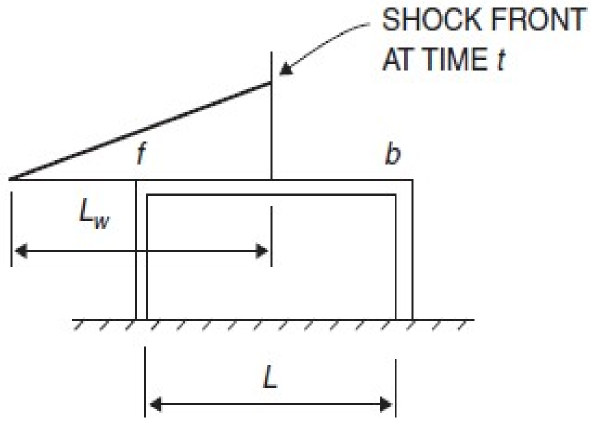

Figure.4. Roof loading

P_r over pressure peak reflected, pressure peak positive Pso, the time clearing t_c, S – width or height (smaller) of structure. G – width or height (larger) of structure, and C_r – sound velocity, C_d – drag coefficient & value is 1.0. Fig.2 to Fig.4 represents the blast load acting on front wall, roof and rear. Table 1 and Table 2 represents the blast load parameter and Input parameter of the blast load.

Table 1. Blast load Parameter

Sl no	Blast load Parameter	Magnitude
1	Charge weight (W)	2000 kg
2	Range (R)	50 m
3	New weight (20% increase Factor of safety)	2400 kg
4	Shock front velocity (U_s)	0.44 m/msec
5	Clearing time (t_c)	20.5 msec
6	Total time ($t_{OF)}$)	27.6 msec
7	Peak dynamic wind pressure	74.3 kPa

The input parameter of the front wall load is shown in Table 3.3

Table 2 Input parameter of blast to the SDOF system

Point No	R (m)	Z (m/kg$^{1/3}$)	P_{so} (kPa)	t_a (msec)	L_w (m)	t_o (msec)	i_s (kPa-msec)	P_r (kPa)	i_r (kPa-msec)
1	50.0	3.73	74.3	69.0	12.2	52.2	1025	191.1	2338

2.2. Base isolations with lead rubber bearing

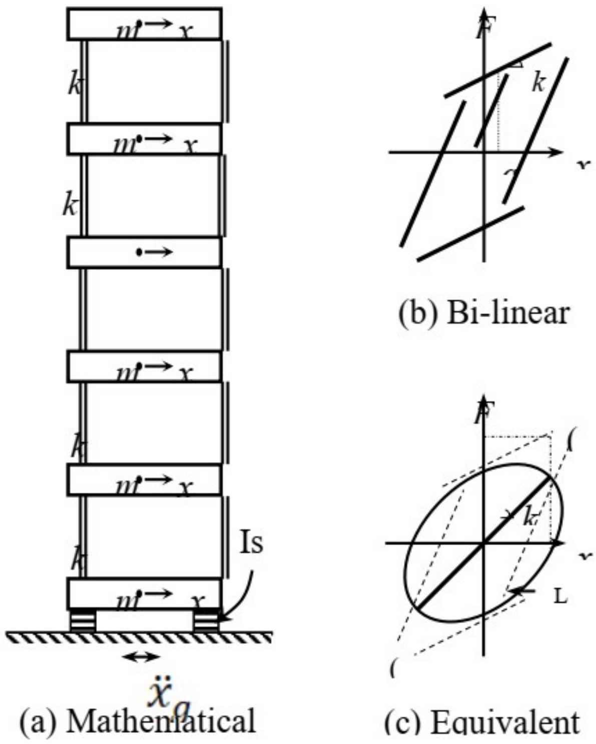

Figure.5. Model of N-story base-isolated

Idealized model mathematical N story base isolated building considered in this studied is represented in Fig.5.

$$[M_s]\{\ddot{x}_s\} + [C_s]\{\dot{x}_s\} + [K_s]\{x_s\} = -[M_s]\{r\}(\ddot{x}_b + \ddot{x}_g)$$

(1)

where $[M_s]$, $[C_s]$ and $[K_s]$ are the mass, damping and stiffness matrices of the superstructure, respectively; $\{x_s\} = \{x_1, x_2, \ldots x_N\}^T$, $\{\dot{x}_s\}$ and $\{\ddot{x}_s\}$ are the unknown relative floor displacement, velocity and acceleration vectors, respectively; $\ddot{x}_b$ and $\ddot{x}_g$ are the relative acceleration of base mass and earthquake ground acceleration, respectively; and $\{r\}$ is the vector of influence coefficients.

The corresponding equation of motion for the base mass under earthquake ground acceleration is expressed by

$$m_b\ddot{x}_b + F_b - k_1x_1 - c_1\dot{x}_1 = -m_b\ddot{x}_g$$

(2)

where m_b and F_b are the base mass and restoring force developed in the isolation system, respectively; k_1 is the story stiffness of first floor; and c_1 the is first story damping.

The restoring force developed in the isolation system, F_b depends upon the type of isolation system considered and approximate numerical models shall be used.

2.3. M.R. Damper

For controlling linear viscous fluid to high yield strength, a semi solid, free flowing reversibly change, magnetic field a solution presence of hydraulic cylinder present in a Magneto Rheological damper. Fig 6 shows a schematic diagram of 20-ton MR damper. The below equations show the governing equations of MR damper.

$$f_d = c_{v1}\dot{y} + k_{a1}(x_d - \acute{x}) \qquad (3)$$

$$\dot{Z} = -\gamma|\dot{x}_d - \dot{y}|Z|Z^{n-1}| \quad - \beta(\dot{x}_d - \dot{y})|Z^n| + A(\dot{x}_d - \dot{y}) \qquad (4)$$

Solving the above equation, $\dot{y}$ gives

$$\dot{y} - \frac{1}{(c_o + c_{vl})}\{\alpha Z + c_o\dot{x}_d + k_o(x_d - y)\}$$

(5)

Where z is the evolutionary variable that accounts for the history dependence of the response, x_d is the damper displacement, $\dot{x}_d$ is the velocity across the damper, k_{al} is the accumulator stiffness, c_{vl} is the viscous damping at the lower velocity of the model to produce the roll-off, c_o is the viscous damping at larger velocity, k_o is the stiffness of the larger velocity and x^i is the initial displacement of the spring and α, β, γ , n and A are the shape or characteristic parameters of the model.

The model parameters α, c_o and c_{vl} depend on the voltage to the current driver as follows

$$\alpha = \alpha_a + \alpha_b u, \qquad c_o = c_{0a} + c_{0b}u \quad \text{and} \quad c_{vl} = c_{la} + c_{lb}u \qquad (6)$$

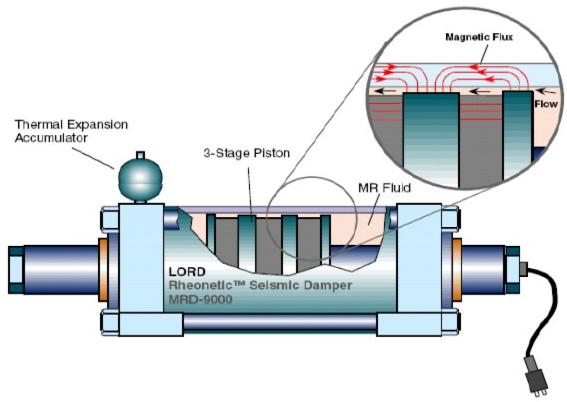

Figure.6. MR damper of 20 ton of schematic

representations [11]

While the filtered voltage u determined by the applied voltage v to the control circuit is as follows

$$\dot{u} = -\eta(u - v) \tag{7}$$

3.0 Numerical Results

The single degree of freedom system subjected to blast load. The system consists of three components that is front wall, rear wall and roof. The input parameter is load that is pressure time curve. The load acting on the front wall, rear wall and roof are represented in Fig.7, Fig.8 and Fig.9. The maximum load acting on the front wall is 188 kPa, the maximum time occurs is 28msec. The maximum load acting on the rear wall is 40kPa , the maximum time occurs is 85 msec00 and the maximum load acting on the roof is 38kPa, the maximum time occurs is 78msec.

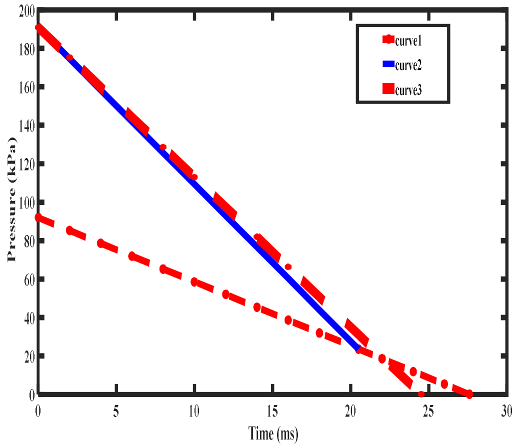

Figure.7. Front Wall Loading

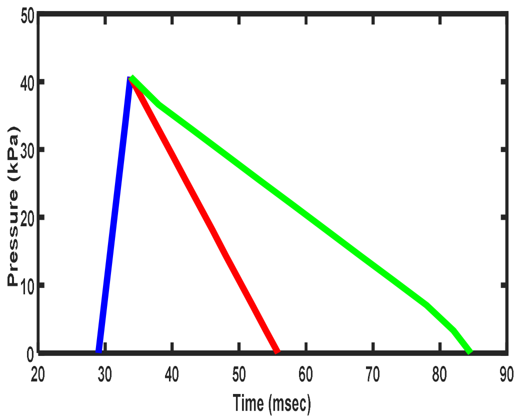

Figure.8. Rear Wall Loading

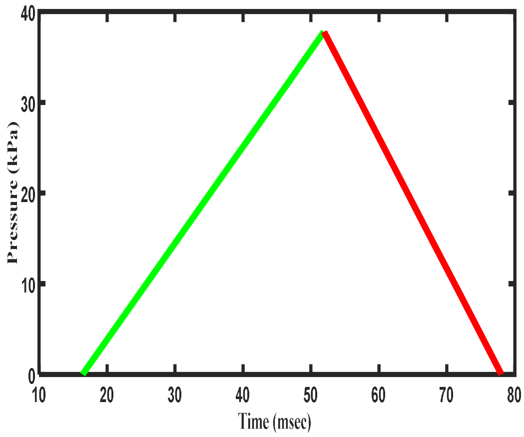

Figure.9.Roof wall Loading

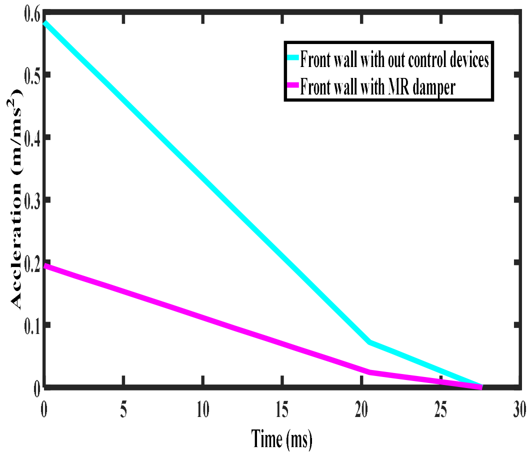

Figure.10. Response of blast load on front wall along acceleration with and without MR damper

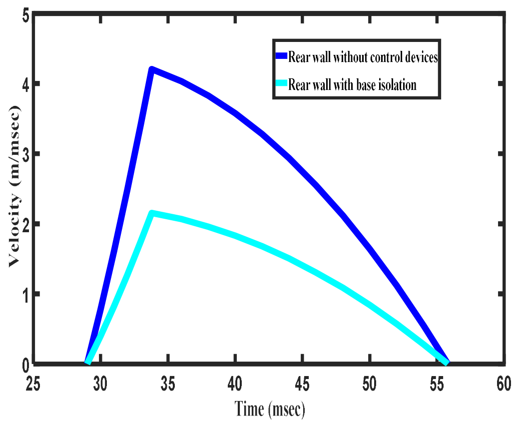

Figure.11. Response of blast load on rear wall along velocity with and without base isolation

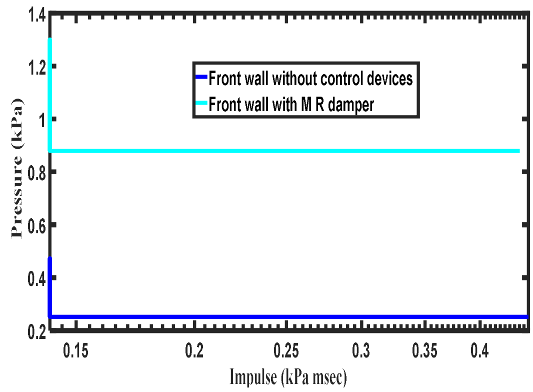

Figure.12. Increase of pressure impulse curve of SDOF with MR damper subjected to blast load on front wall

Fig.10. shows the reductions of accelerations on front wall by using MR Damper. The accelerations is reduced from 0.58 m/msec^2 to 0.2 m/msec^2 . Fig.11. shows the reductions of velocity on rear wall by using Base isolations. The velocity is reduced from 4m/msec to 2m/msec. The pressure falls below the right corner represents the pressure impulse will be safe for the structural system is safe. The Fig.12 represents the by using M.R. Damper, the increase of pressure and impulse will not cause damage to the structure.50% increase of the pressure and impulse will be the safe to the structural system exposed to blast load.

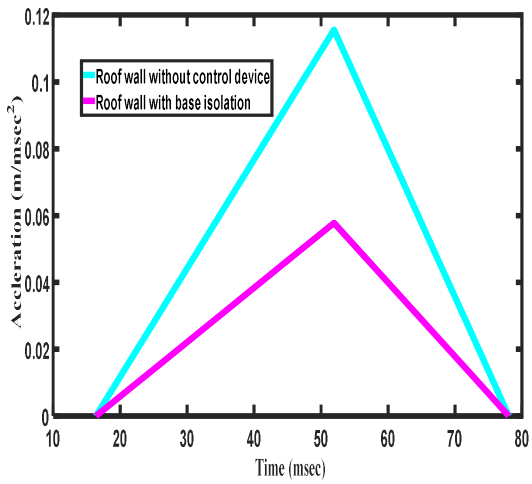

Figure.13. Response of blast load on roof along acceleration with and without Base isolation

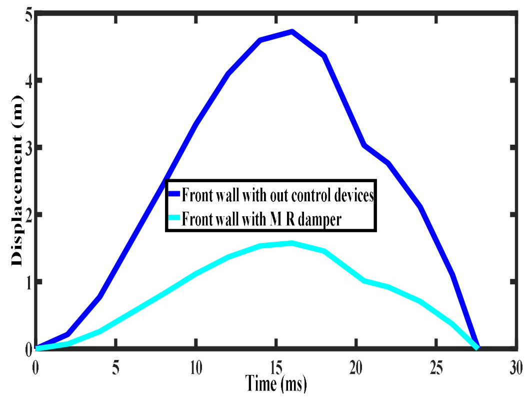

Figure.14. Response of blast load on front wall along displacement with and without MR damper

Table 3. Reductions of response of rear wall subjected to blast load

Sl no	Parameter	Bare frame	Base isolation	MR damper
1	Displacement (m)	32	15	10
2	Velocity (m/msec)	6	2.8	1.8
3	Accleration (m/msec^2)	0.19	0.06	0.04
4	Pressure (kPa)	0.08	0.4	0.5
5	Impulse (kPa-msec)	$7*10^{-4}$	$9.5*10^{-4}$	$9*10^{-4}$

Fig.13. shows the reductions of the accelerations on roof by using the base isolations from 0.118 m/msec^2 to 0.06 m/msec^2. Fig.14. shows the reductions of the displacement on front wall by using the M.R. Damper from 4.8m to 1.5m by using M.R. Damper.

4. Conclusions

From the previous researcher studies only, the load is acting on the front wall and rear wall are calculated. In presented work load is acting on the roof is calculated. The response on the various component of the SDOF system is also calculated. The response is reduced by using the Base isolations and M.R. Damper.

i. In case of front wall loading the 69% of displacement is reduced by using MR damper, 71% of the velocity is reduced by using MR damper, 65% of acceleration is reduced by using MR damper,
ii. In case of rear wall loading the 60% of displacement is reduced by using base isolation, 54% of the velocity is reduced by using base isolation, 54% of acceleration is reduced by using base isolation.
iii. In case of roof loading the 68% of displacement is reduced by using MR damper, 70% of the velocity is reduced by using MR damper, 79% of acceleration is reduced by using MR damper.

Disclosures

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