International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 5, Issue 12, pp 68-72, December-2021

https://doi.org/10.47001/IRJIET/2021.512014

Review on Performance of Reinforced Concrete Building Structures under Blast Load

[1]Akshay Kumar Chauhan, [2]Akash Malik

[1]PG Student, Department of Civil Engineering, Galgotias University, Gr. Noida, Uttar Pradesh 203201, India

[2]Assistant Professor, Department of Civil Engineering, Galgotias University, Gr. Noida, Uttar Pradesh 203201, India

***Abstract* - As the terrorist attacks are repeated continuously all around the world. They target the public building for terrorism because their large amount of people is there. The use of a large amount of explosive material that collapses the building component. In previous study analyses the multistory building and frame with different loading and structural configuration. Using different software such as ETABS, SAP2000, ANYSIS, and ABAQUS. Using the Finite element method for time history analysis during the blast. To know the performance of the building of frame using X- plate, Damper, Shear wall, and different Bracing. In this paper focus on understanding the behavior of the reinforced concrete structure under blast load at different standoff distances with different charge weight. TNT is used for explosive material. And study on displacement, storey drift, deflection fundamental frequencies, and stress on structural members. Future studies will be staggered shear wall with different bracing and different blast load and load distances.**

Keywords: Blast Phenomena, TNT, Standoff distance, ETABS, SAP2000, Software, Time History Analysis, and Storey Drift.

I. INTRODUCTION

Blast is a very sudden phenomenon which effects on building or structural members. That happens within a fraction of seconds. Due to this large number of energy come out. Which produces sudden load on structural members? So blast load should be specifically calculated just like wind and high amplitude earthquake. The loss of people's life due to blast could not be reduced if the blast cannot be stopped. The blast which disturbs the stability of the structure members. In recent years Blast in occur due to a large no of terrorist attacks in different countries and due to the explosion of gas plans. "On February 26, 1993, a bomb explodes in the parking garage of 'World Trade Center in New York' in that explosion six peoples wad killed'. 'In April 1995 Alfred P. Murrah Federal Building was used to bomb blast in U.S. state of Oklahoma, there 168 people were killed and 700 of peoples were injured'. 'July 1996, a bomb explodes in Centennial Olympic Park in Atlanta during the Summer Olympics. One person dies, another die of a heart attack, and more than 100 others are injured'. 'Bomb blast suspect Eric Robert Rudolph was arrested in 2003 in Atlanta after being involved in 2000 bombings and other bombings in North Carolina in which one person was killed'. 'On 11 September 2001, the nineteen al Qaeda members hijack four United America passengers' airliners. Another incident happened on 15 April 2013, two bomb blasts explode near the finish line of the Boston Marathon. Due to that three people killed and 264 hurting' [CNN Editorial Research, 2020]". On 12 March 1993 serial of 13 bomb blast in Mumbai due to that more than 1400 were injured. The main Blast explodes in Mumbai which is known as 26/11. Many people's are killed in this attack. Which are highly known terrorist attack and bomb blast in Taj hotel Mumbai in India more than 30 bomb blast happened 26/11 terrorist use the highly explosive material like IED etc. So blast is very dangerous of structural members thus finding out the performance of structure under the blast load is very important. The situation is too essential to decrease the properties of explosion on building structures members. Not only for safety of structure but also reduces the loss of people life. So the main thing is Blast Pressure intensity will depend upon the size of the bomb and distance between standoff and structures. The reflected explosion pressure, incident pressure and arrival time they all are significant limitations which are found from incident wave shown figure.

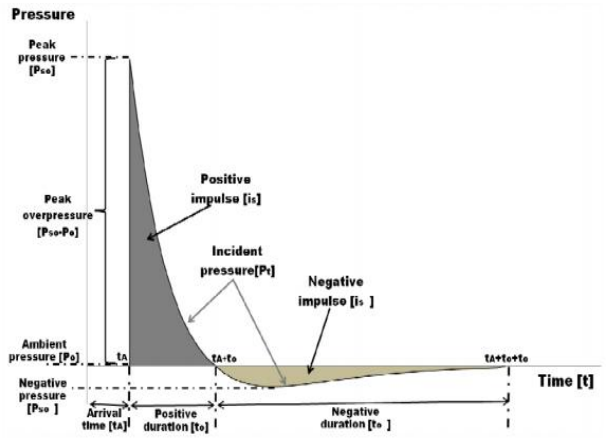

Figure 1: Perfect explosion wave's pressure time history [Vasilis karlos, George solomos, 2013]

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 5, Issue 12, pp 68-72, December-2021

https://doi.org/10.47001/IRJIET/2021.512014

1.1 Perfect Explosion Wave Pressure-Time Characteristics

The above figure shows the relation between the ideal profile of pressure and time in case of a free air detonation wave. That is reached a point at a convinced distance from the blast. The ambient pressure (P_o)is originally equal to the pressure near the element. It undertakes an immediate rise to an ultimate pressure (P_{so}) at the advent time (t_A), while the shockwave front touches that point. The time required for the force to extent its highest rate is very minor. Then it is equal to 0 for design purpose. The peak pressure (P_{so}) is also known as peak overpressure. The velocity of propagation of the shock wave as well as the value of the peak overpressure decrease with growing distance from the explosion epicenter. After getting the peak pressure drops with exponential rate from peak pressure to ambient pressure$t_a + t_o$, t_o. That is called Positive phase duration. The pressure is less (refer as negative) than the ambient value after the positive- time phase of the figure. The positive phase is lesser than the negative phase, in which the minimum value is indicated as (P_{so}^-) and the period is (t_o^-). In this phase, the structure member is exposed to pressure load on building glass. As per research the key structural damage is due to positive impulse phase. The negative impulse phase is less as compare to positive phase. And act on opposite site of building. That is not apply big impact on structure. Therefore the pressure that is under the ambient pressure value should be engaged into calculation. If the whole response of structural during the explosion is measured. [Vasilis karlos, George solomos, 2013].

II. PRESENT STUDIES BY RESEARCHERS

In this investigation G+5 RC building structure was used for investigate gate the storey drift, storey displacement, time period and frequencies in 6 cases with explosive material and different standoff distances. Square buildings are used with the height of 18m, 12m width and 12m long. Story height is 3m. Which is situated at 10m from the ground level. Only positive phase duration or positive pressure is taking into account. Under the call 6 cases the structure is subjected to two different blast load which is 10kg and 20 kg. The standoff distance is 10m, 15m and 20m. The blast analysis under the IS 4991: 1968 with ETABS Software under Time history analysis. The column size is 450x450mm, the beam size is 230x300mm, and the slab thickness is 120mm. with the increase in the standoff distance and charge the time duration of force applied is increase but the force is reduced on the front face. As per the analysis, the story displacement is lesser in 10kg, 20m case in the first story, and high in the sixth storey. This means the standoff distance is inversely prepositional to damage of structure and displacement. The storey drift is high in the first storey with 20kg, 10m charge, and standoff blast. The intensity of blast pressure is lower on the upper storey due to an increase of standoff distance from bottom storey to top storey. Storey drift is more in the first storey as compared to the sixth storey in all analysis cases. [K Prabhakar, RamavathSreenu, 2018]

The Six storey 14x14m building is use to analyze under surface blast with charge of 200kg, 400kg, and 600kg with 20m,40m, and 60m standoff distances. The bottom floor height is 3.5m and other is 3m each. Blast load is applied in the x direction. With different loading condition. The software is use ETABS2016 time history analysis. Blast source is closer to the building the displacement is high. When the Standoff distance decreases and charge weight increases, the storey displacement of the building increases. When blast charge is closer to building the drift and displacement is more. The displacement, velocity and acceleration of joint is increase by increases of charge weight and standoff distance. The storey drift and displacement is less when using the shear wall and X steel bracings corner periphery of building. Building is safer when using the X steel bracing and shear wall. [Megha S. Mahaladkar, Ramya K, 2019]

In this investigation, response of Reinforced concrete frame under positive phase and positive and negative phase of blast is take into account. Five models, three-storey-three bay bare fame and three – storey- three bay fame model were used with column and beam size 300mmx300mm, 115mm and 230mm thick infill wall with or without opining. Also using 500kg and 1500kg charge weight with 10m standoff distance. Using TNT load with flow out boundary condition by ANSYS software. Maximum displacement comes when positive and negative phase is take in account under 115mm and 230mm thick infill wall and infill wall with opening under 500kg and 1500kg charge load. Deflection is more in all frame while both positive and negative phase considered. Deflection is also more in three storey- three bay bare frame as compare to three storey- three bay frame 230mm thick wall with or without opening. Deflection is also more in three storey- three bay bare frame as compare to three storey- three bay frame 115mm thick wall with or without opening. The deflection is also more in three storey- three bay frame with 230mm thick infill with opening as compare to three storey- three bay frame with 230mm infill wall without opening. It is also show the deflection in three storey-three bay frame with 115mm thick infill wall with opening is more compare to three storey three bay frame with 115mm thick infill without opening. And deflection in three storey-three bay frame with 115mm thick infill wall is more as compare to three storey-three bay frame with 230mm infill wall without opening also. [MeenuMurali, Sujisha V, 2016]

In this investigation seven storey reinforced concrete building is used. The dimension of building is 16m length 22m

ISSN (online): 2581-3048
Volume 5, Issue 12, pp 68-72, December-2021
https://doi.org/10.47001/IRJIET/2021.512014

in x- direction, and 24.5m height. With 150mm thick slab and 230mm thick wall. Bracing is used with ISMB450 properties. Considered live, floor finish and wall load as 3KN/m^2, 1.67KN/m^2 and 14.14KN/m^2. The SAP2000 is used for analysis. The 100kg RXD is used as explosive material with 10m, 20m, 30m, 40m, 50m, and 60m standoff distances. Analyze the building with or without bracing to find out the storey drift and displacement within permissible limit as well. UFC 3-340-02 code is used for blast load calculation. As per result the displacement is increases with bottom storey to top storey but the drift is decreases from bottom to top with or without bracing, with 10m to 60m respectively. Storey drift have higher value at second storey where bracing is not used. And maximum drift at first storey in bracing structure. Braced structure is reduce the displacement and drift very highly. If stand drift is near the structure the damage, storey drift ad displacement is too high. [Mohammed Moinuddin, Kiran K. K, 2018]

This investigation is run round about structure having 4 bay of 3.5m in x, y and z direction using M30 and fe415 concrete and steel respectively. In this analysis using four different model such as Normal framed structure, increased sized beam and column cross- section, Normal frame structure with 150mm thick shear wall and X shaped steel channel bracing (ISLC200). The charge weight is 100kg and 300kg with 30m and 20m standoff distances with each charge weight. Applied live load is 3KN/m^2. Blast load is calculated by IS4991: 1968. It is assume that loads on front face, roof and side walls of building is increases with the decreases of standoff distance, with increases of charge weight in all cases at center, side and edge of front face, roof and side walls respectively. Normal frame structure is not satisfied the displacement limit and storey drift by IS code provision. In increased size framed model case that also not satisfy the code provision under blast load, it is not economical for increase size for blast resist because huge size is required. Shear wall is more effective for blast resistance as compare to shear wall. Outer shear wall and bracing is also beneficial to resist overturning, moment, and large storey shear. [Muhammed Hasil, Dr. Abhay Sharma, 2016]

In this investigation evaluate the performance of structure under the seismic and blast load with the using of XPD device and X plate. XPD device is a passive control device used for endures cycle of stable yielding deformation of structure. XPD also provides the additional stiffness and damping structure. Moment resistance frame is used with column size 0.5x0.5m and beam size 0.3x0.5m under the time history analysis with the help of SAP2000. With the Using of X- plate the energy dissipation is increase as compare as compare to without using the damper. The extreme displacement of structure is reduced by 50% by using of X- plate damper under the seismic and blast load in given time. And storey displacement is also decreases with using of X- plate damper. So the result of X-damper is beneficial for blast and seismic load. [N. Omprakash Reddy, AtulkumarManchalwar, 2019]

This Paper investigate the blast effect on RC two story building with three different aspect ratio of building. They us blast locations changed distances from the center of column. In second blast case, the blast locations changed distances from the side column. The software is used ANYSIS and program are used AUTODYN with 1D and 3D blast problems. Which is design for solving high non-linear dynamic problems. The three building models are used in this analysis. The Floor to floor story height is 4.2m, depth is 6m length is 3m, 6m and 9m and aspect ratio 0.5, 1, 1.5 respectively. The load is used such as Case 1- symmetrical loading with blast distances such as 1.5, 3, 6, 9 m with blast at middle of column and corner column respectively. Case 2- skew loading with blast distances such as 1.5, 3, 6, 9 m with blast at middle of column and corner column respectively. 1000Kg TNT is used as explosive material. The result is that over pressure and temperature is decreases with increasing of standoff distance of blast from the building. And the displacement is reducing with increase of standoff distance of blast from the building. In skew loading the displacement of column c3 due to angle of incidence [Osman Shallan, Atef Eraky, Tharwat Sakr, Shimaa Emad, 2014].

Comparison of fundamental frequencies between reinforced concrete building and SIMCON high rise building under the blast load effect. SIMCON is special type of concrete. Rectangular shaped building are used to understand the fundamental frequencies and storey displacement. Total 12 building models are use in which 6 models using reinforcement concrete building and remain 6 models using SIMCON concrete building. In this analysis 3, 5, 7, 9, 11 and 15 storey building models. In all cases the floor height is 3 m. In all cases Beam and column size were different. Brick wall thickness was 230mm in all cases. Using M60 concrete and Fe416 steel. Dead load, live load, and earthquake load was also considered. IS 4991: 1968 for aspect such as 0.5, 1 and 1.5. In first case blast load and ETABS Software was used for time history analysis. In this investigation fundamental frequencies for all SIMCON buildings models are greater than reinforced concrete buildings models. In SIMCON building increase in the frequencies is due to its high strength of materials, high energy absorption capacity of material and high ductility when the blast wave reaches the building. The dynamic behavior of Reinforced building is less than SIMCON building. The height of SIMCON building model increases, when its frequency decreases, but then also it is larger than Reinforced concrete building. The Fundamental frequencies of SIMCON building is greater than Reinforced

ISSN (online): 2581-3048
Volume 5, Issue 12, pp 68-72, December-2021
https://doi.org/10.47001/IRJIET/2021.512014

concrete building. Storey displacement of SIMCON building is less than Reinforced concrete building. When the height of building is rises the story displacement is also rises but the displacement are fewer in SIMCON building. Blast load is rises when the standoff distance between building and explosive material is decreases. The effect of blast n SIMCON building as compare to Reinforced building. So the blast effect on SIMCON building is less Reinforced building [SwathiRatna. K, 2016].

This investigation on five storey 8 bays 3m length bays in X and Z direction with 3m height of each storey space building, with simple concrete bare frame and concrete frame with shear wall. The size of column is 0.6mx0.6m, beam size 0.6mx0.3m with 0.25m thick shear wall. Floor load is $5KN/m^{2.}$ With 5% damping hard soil is considered. The weight of charge is 300kg, 200kg, 100kg with 15m, 20m and 25m. The analysis done by STADD Pro.V8i. As per investigation the displacement is more in bare frame as compare to frame with shear wall under 300kg, 200kg charge at 15m charge distance. No displacement is shown with 100kg charge at 15m distance in both cases. The joint displacement x, z, r direction is more in simple bare frame as compare to frame with shear wall under 300kg at 15m distance. But some joint displacement more in shear wall frame as compare to simple bare frame in x, z and r direction under different charge load and charge distances. It is also see the displacement is more in shear wall structure as compare to without shear wall structure with different charge ad charge distances. High stress is show due to heavy weight of charge. The storey drift is also changeable due to charge weight and charge distance in shear wall and without shear wall frame cases. To protect the structure against the blast load use steel plate. [Simranjitsingh, Charanjeetsingh, Ankush Thakur, Dushayantsinghyadav, 2018]

This investigation is carried out by ABAQUS software with C3D8/C3D8R finite element. A Two dimensional 4-storey RC framed, with first floor is 5m height and other 3m height is used. Width of frame is 3m each bay. Different column and beam size such as 30x30cm and 25x50cm take into account respectively. Main Goal is to make blast resistance design of external column. Two different configuration column is used such as 200mmx200mm concrete filled steel tube and 5mm thick, steel column restricted by RC concrete, the W4x13 steel and 4-10mm diameter bar are used. Axil load is same in all cases. 1 Ton TNT is used for blast at 5m distance from the structure and 1m high above the ground. UFC 3-340-02 is use for blast load calculation. Von Mises stress is developed in ordinary concrete model, and stress mandate on frame joints is both compression and tension but latter is not shown. The stress figure is take in 0.2s. For better understanding of bending moment use SAP2000 again. It's shown the different between dynamic and static condition is significant. The progressive damage is happen in concrete compression. Which is track by damage index? Column series is most effected by blast load many joints are fail in concrete and steel. The concrete filled tube and steel column confined by RC concrete is give better response against blast. [Yasser E. Ibrahim, Mostafa A. Ismail, Marwa Nabil, 2017]

III. CONCLUSION

In all the above investigations, they are trying to find out the story displacement, fundamental frequencies, and time-history response of building with different loading and different structural model configuration. They use many models and perform the analysis by many software like ETABS, ANSYS, and STADD. PRO etc. by response spectrum method and all. The studies comply with the Story drift, story displacement, fundament frequencies depends upon the openings, loading condition, openings location of shear wall in structure. But the analysis of staggered shear wall structure with bracing was missing in all studies. So the next study blast loading on different staggered shear wall structures with Different bracing should be performed.

ACKNOWLEDGEMENT

We would like to acknowledge Asst. Prof. Akash Malik, department of Civil engineering, Galgotias University, for his valuable guidance, ideas, and inspiration.

REFERENCES

[1] K Prabhakar, RamavathSreenu, (2018) "Analysis of Reinforced Concrete Building under Blast Loading", International Journal of Latest Transactions in Engineering And Science (IJLTES) Volume 4 Issue 4.

[2] Megha S. Mahaladkar , Ramya K.(2019) "Analysis of Multi-Storey RC Building Subjected to Blast Load using Time History Method International Journal of Innovative Science and Research Technology, ", Volume 4, Issue 6.

[3] MeenuMurali, Sujisha V. (2016) "Study on the Response of RC Frames Subjected to Blast Loading" ,International Journal of Engineering Research Technology (IJERT), Vol. 5 Issue 08.

[4] Mohammed Moinuddin, Kiran K. K.(2018) "Analysis Reinforced Concrete Structure Subjected to External Surface" , International Research Journal of Engineering and Technology (IRJET), Volume: 05 Issue: 07 |

[5] MuhammedHasil, Dr. Abhay Sharma, (2016) "Response of RC Structure Exposed to Explosion",

ISSN (online): 2581-3048
Volume 5, Issue 12, pp 68-72, December-2021
https://doi.org/10.47001/IRJIET/2021.512014

International Journal of Science, Engineering and Technology, , Volume 4 Issue 4

[6] N. Omprakash Reddy, AtulkumarManchalwar, (2019) "Performance of Moment Resisting RC Building Equipped With X-Plate Damper under Seismic And Blast Loading", International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-9 Issue-2.

[7] Osman Shallan, AtefEraky, TharwatSakr, ShimaaEmad(2014) "Response of Building Structures to Blast Effects", International Journal of Engineering and Innovative Technology (IJEIT) Volume 4, Issue 2.

[8] SwathiRatna. K (2016) "Analysis of rcc and simcon buildings subjected to blast effects" ,International Journal of Civil Engineering and Technology (IJCIET) Volume 7, Issue 4.

[9] Simranjitsingh, Charanjeetsingh, AnkushThaklur, Dushayantsinghyadav, (2018) "Performance of Shear wall structure under blast loading" , Advanced Structures, Material and methodology in civil engineering, Paper code S-129,.

[10] US Terrorist Attacks Fast Facts (2020),CNN Editorial Research.

[11] Vasilis karlos, George solomos (2013), "Calculation of Blast Loads for Application to Structural Components", European Commission Joint Research Centre Institute for the Protection and Security of the Citizen.

[12] Yasser E. Ibrahim, Mostafa A. Ismail, Marwa Nabil (2017) "Response of Reinforced Concrete Structures under blast load", Elsevier Ltd.

AUTHORS BIOGRAPHY

Akshay Kumar Chauhan received his Diploma in Civil Engineering in 2014 from Teerthanker Mahaveer University. He also received his Bachelor of Engineering in 2018 from Dr APJ Abdul Kalam University. Now he is Pursuing his Master of Technology (Structural Engineering) from Galgotias University. His Current research focus is on Seismic behaviour of staggered shear wall and X bracings Structures.

Akash Malik is an Assistant Professor of Structural Engineering in the Department of Civil Engineering at Galgotias University, Greater Noida. He obtained his Master's in Structural Engineering from the Maharishi Dayanand University, Rohtak in 2019. His research interests are Structural Prediction of Buckling of Steel plates with Cutouts, Reliability of a timber truss considering its joints. Prediction of compressive strength of recycled aggregate concrete: Genetic Programming and GRNN approach.

Citation of this Article:

Akshay Kumar Chauhan, Akash Malik, "Review on Performance of Reinforced Concrete Building Structures under Blast Load" Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 5, Issue 12, pp 68-72, December 2021. Article DOI https://doi.org/10.47001/IRJIET/2021.512014

****

