Structural Analysis of Blast Resistant Building

Ms. Shikalgar Sana Rafik [1], Prof. V.V. Shelar[2]
[1]Dept of Civil Engineering
[2]Assistant Professor, Dept of Civil Engineering
[1, 2] Trinity College of Engineering & Research, Pune

Abstract- *The increase in the number of terrorist attacks especially in the last few years has shown that the effect of blast loads on buildings is a serious matter that should be taken into consideration in the design process. Although these kinds of attacks are exceptional cases, man-made disasters; blast loads are in fact dynamic loads that need to be carefully calculated just like earthquake and wind loads. The objective of this study is to shed light on blast resistant building design theories, the enhancement of building security against the effects of explosives in both architectural and structural design process and the design techniques that should be carried out. Firstly, explosives and explosion types have been explained briefly. In addition, the general aspects of explosion process have been presented to clarify the effects of explosives on buildings. To have a better understanding of explosives and characteristics of explosions will enable us to make blast resistant building design much more efficiently. Essential techniques for increasing the capacity of a building to provide protection against explosive effects is discussed both with an architectural and structural approach.*

Keywords- Blast load, Shear wall, ETABS, Explosive Effects.

I. INTRODUCTION

Damage to the building causing loss of lives is a factor that has to be minimized if the threat of terrorist activities cannot be stopped. This paper gives guideline measures for overcoming the effects of explosions, hence providing protection to the structures and lives. Ductile elements like steel and RCC can absorb a significant amount of strain energy, whereas brittle elements like PCC, timber, brick masonry, glass, etc. fail abruptly. IS 4991-1968 has failed to deal with the different kinds of loads developed in the dynamic response of a building to bomb blast. They need further explanation as the engineers have no guidance on how to design or evaluate structures for the blast anomaly for which an elaborated understanding is required. Though this topic is of prime importance in the military circles and important data derived from tests and experiments have been restricted to army use only. Yet a number of publications are available in the public domain by the US agencies.

In this topic, exploration of the literature on blast loading, explanation of special conditions in defining these loads and also the exploration of the vulnerability assessment and risk management of structures with standard structural analysis software having nonlinear capabilities. In the past 2-3 decades, substantial importance has been given to problems related to blasting and earthquake. Problems on Earthquake despite being very old, most of the knowledge on this subject has been agglomerated during the past fifty years but in the case of blast loading, this condition is different. Disasters such as Manchester Arena bombing, UK, 22nd May 2017, at the Ariana Grande’s pop concert, Baghdad Bombing, Iraq, 3rd July 2016, terrorist bombings of the 13th November 2015 Paris attacks were a series of coordinated terrorist attacks in Paris and its northern Suburb, Mumbai 26/11 terrorist attack and many more have demonstrated the need for a thorough examination of the structures subjected to blast loads. With the present knowledge and software, it is possible to perform analysis of structures exposed to blast loads and to evaluate their response. Blast loading or impulse loading is a type of load acting for a very short duration of time. Graphically, blast loading is drawn as a triangle, referring as triangular loading.

A. Blast Load

To resist blast loads, the first requirement is to determine the threat. The major threat is caused by terrorist bombings. The threat for conventional bomb is defined by two equally important elements, the bomb size, or charge weight, and stand-off distance- the minimum guarantee distance between the blast source and the target. Another requirement is to keep the bomb as far as possible, by maximizing the keep out distance. No matter what size the bomb, the damage will be less severe the further target from the source. Structural hardening should be actually the last resort in protecting a structure; detention and prevention must remain the first line of defense. As terrorist attacks range from the smaller letter bomb to gigantic truck bomb as experienced in the Oklahoma city, the mechanics of a conventional explosion and their effects on a target must be addressed.

II. FEATURES OF BLAST LOADS

Blast loads cannot and should not be compared to seismic load. Unlike Seismic load, blast loads occur for a very short duration. Thus material strain rate effects become a crucial point that must be considered for defining connection performances in case of blast loads. However, it is not possible to make a building both seismic proof and blast proof at the same time and blast loads are applied on a structure irregularly. Unlike seismic load intensity, blast load intensity is of very magnitude in a particular region or space for a fraction of a second

A. Structural Form and Internal Layout

Structural form is a parameter that greatly affects the blast loads on the building. Arches and domes are the types of structural forms that reduce the blast effects on the building compared with a cubicle form. The plan-shape of a building also has a significant influence on the magnitude of the blast load it is likely to experience. Complex shapes that cause multiple reflections of the blast wave should be discouraged. Projecting roofs or floors, and buildings that are U-shaped on plan are undesirable for this reason. It should be noted that single story buildings are more blast resistant compared with multi-story buildings if applicable. Partially or fully embed buildings are quite blast resistant. These kinds of structures take the advantage of the shock absorbing property of the soil covered by. The soil provides protection in case of a nuclear explosion as well. The internal layout of the building is another parameter that should be undertaken with the aim of isolating the value from the threat and should be arranged so that the highest exterior threat is separated by the greatest distance from the highest value asset. Foyer areas should be protected with reinforced concrete walls; double-dooring should be used and the doors should be arranged eccentrically within a corridor to prevent the blast pressure entering the internals of the building. Entrance to the building should be controlled and be separated from other parts of the building by robust construction for greater physical protection. An underpass beneath or car parking below or within the building should be avoided unless access to it can be effectively controlled. A possible fire that occurs within a structure after an explosion may increase the damage catastrophically. Therefore the internal members of the building should be designed to resist the fire.

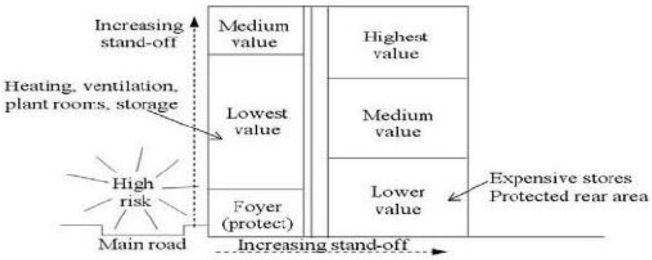


Fig 1: Stand-Off Distances

III. BLAST LOAD CALCULATION

As Per IS:4991 1968

Determination of Blast Load

Blast Parameters

Charge Weight Considered, W=	**200**	kg	(0.1 Tonnes)
Stand Off Distance Considered=	**10**	m	(For Industrial Structures)

Characteristics of the Blast

Scaled Distance, X= (Actual Distance/$W^{1/3}$)

= ($20/0.2^{1/3}$)

= **17.099759** m

From Table 1 of IS: 4991-1968, Assuming **P_a=1kg/cm^2**

P_{so}=	**5.900**	kg/cm^2
P_{ro}=	**28.231**	kg/cm^2
q_o=	**6.84606**	kg/cm^2

The Scaled Times for the Scaled Distance from Table 1,

t_o=	**10.5499**	x (0.2)1/3=		milli seconds
t_d=	**6.64**	x (0.2)1/3=	**3.885**	milli seconds

M=Mach Number= √(1+((6/7)x(Pso/Pa))

= **2.461**

a= Velocity of Sound= **344** m/sec

U=M x a 846.62746 **0.847** m/milli seconds

Pressure on the structure

Height of the structure,**H=**	**87.3**	m
Width of the building, **B=**	**12**	m
Length of the building, **L=**	**12**	m
S= H or B/2, whichever is less=	**6**	m

t_c =	(3S/U)=	**21.26**	milli seconds	<t_d
t_t =	(L/U)=	**14.17**	milli seconds	<t_d
tr=	(4S/U)=	**28.35**	milli seconds	<t_d

As **tr** < **td**, no pressure on the back face is considered

For Roof and Side Faces, Cd= **-0.2**

Pso+Cdqo= **4.530788** **kg/cm2**

V. RESULTS FOR BLAST LOADING

A. Bracing With Shear Wall And Shear Wall At Odd And Even Floor

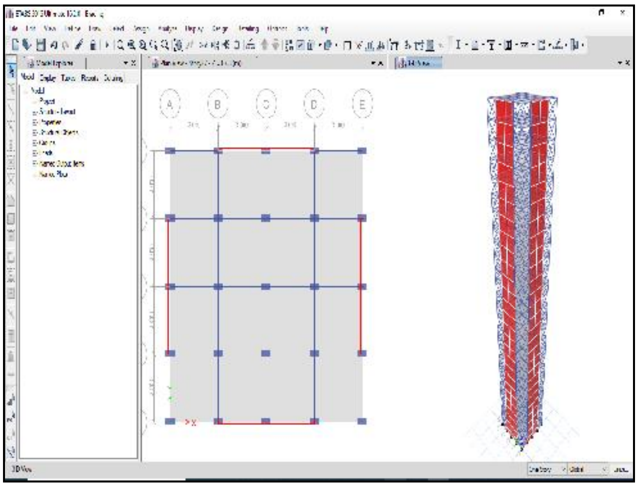


Fig 2 Bracing With Shear Wall

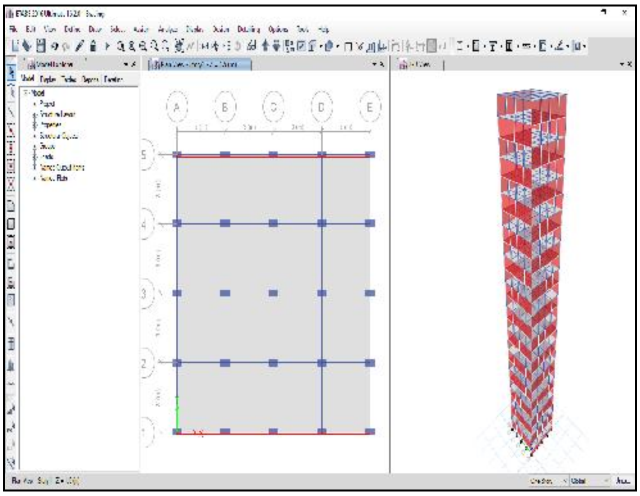


Fig 3 Shear Wall at Odd Floor

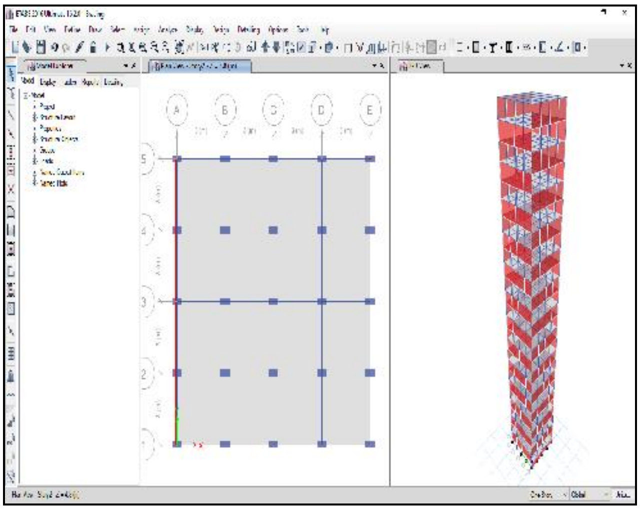
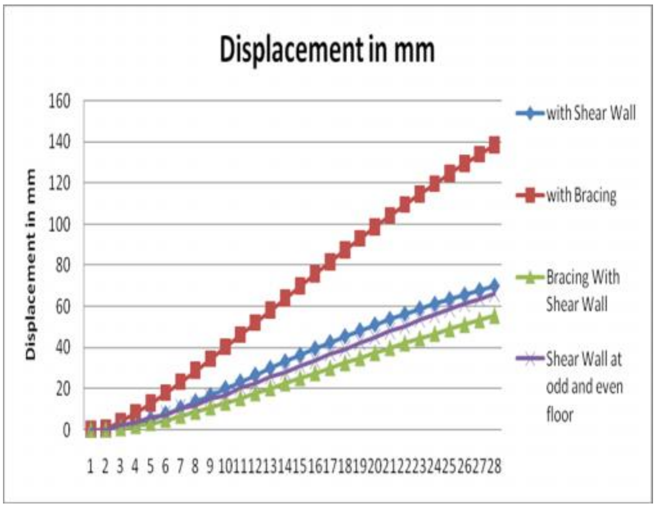


Fig 4 Shear Wall At Even Floor

Table 1 Displacement in mm

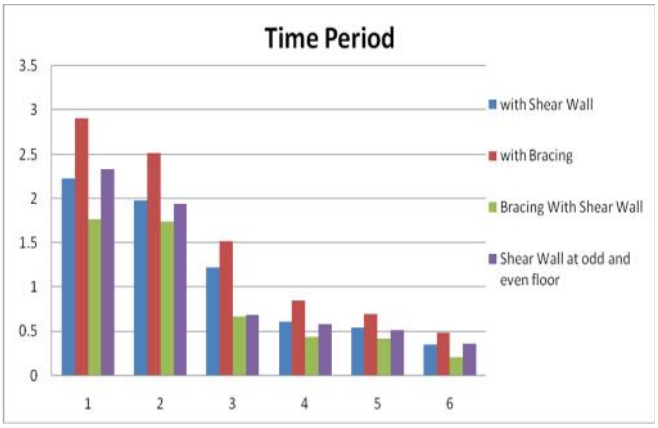
Displacement in mm				
Storey	**with Shear Wall**	**with Bracing**	**Bracing With Shear Wall**	**Shear Wall at odd and even floor**
27	70.02	138.664	55.495	66.255
26	67.913	134.132	53.339	63.802
25	65.774	129.478	51.152	61.223
24	63.567	124.685	48.938	58.76
23	61.279	119.754	46.69	55.999
22	58.901	114.683	44.407	53.531
21	56.426	109.477	42.088	50.602
20	53.852	104.139	39.736	48.143
19	51.178	98.679	37.352	45.064
18	48.406	93.104	34.941	42.634
17	45.537	87.426	32.508	39.428
16	42.579	81.658	30.058	37.054
15	39.536	75.815	27.598	33.751
14	36.418	69.913	25.138	31.466
13	33.235	63.97	22.686	28.102
12	30.001	58.007	20.252	25.944
11	26.73	52.045	17.849	22.56
10	23.444	46.111	15.489	20.574
9	20.165	40.231	13.19	17.218
8	16.924	34.437	10.968	15.456
7	13.757	28.765	8.844	12.183
6	10.712	23.256	6.845	10.703
5	7.849	17.959	5.001	7.574
4	5.245	12.933	3.351	6.441
3	2.998	8.25	1.945	3.522
2	1.24	4.012	0.851	2.816
1	0.168	0.583	0.144	0.107
0	0	0	0	0



Graph 1 Displacement in mm

Table 2 Time Period

Time Period				
Mode	with Shear Wall	with Bracing	Bracing With Shear Wall	Shear Wall at odd and even floor
1	2.23	2.91	1.769	2.331
2	1.98	2.517	1.738	1.945
3	1.22	1.52	0.667	0.689
4	0.611	0.854	0.436	0.579
5	0.545	0.698	0.423	0.513
6	0.356	0.49	0.213	0.364



Graph 2 Time Period

VI. CONCLUSION

Structural damages caused by blast loading are the combination of both immediate effects and consecutive hazards, among which is progressive collapse. This catastrophic failure mode occurs when the initial failure of one or several key load-carrying members causes a more widespread failure of the circumventing members what leads to consummate collapse of the whole structure. Consequently, it is of great paramount to investigate and ameliorate the replication of structures to blast loading. A bomb explosion nearby a building can cause catastrophic damage to the building's external and internal structural frames, collapsing of walls and shutting down of critical life-safety systems. Loss of life and injuries to occupants can result from many causes, including direct blast-effects, structural collapse, debris impact, fire, and smoke. The indirect effects can cumulate to inhibit or avert timely avoidance, thereby contributing to supplemental casualties. The main intent of this Study is to through light on the design of blast resistant buildings and to know the response of a structure when subjected to blast loads utilizing ETABS software with prominence given on different Standoff distances of the blast and incorporating different charge weights of TNT according to the IS CODE 4991. This study examined at blast loads applied to buildings with shear walls and bracing. According to the findings of the study, shear walls produce better economic results than bracing. For bracing, we replaced bracing with BRB and analyzed blast loads again because BRB delivers economic results when compared to bracing. As a consequence of the study, we must recommend that if you only use bracing, use BRB instead of conventional bracing to minimize blast effects on the building.

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