A PAPER ON CRITICAL ANALYSIS ON PERFORMANCE OF RCC STRUCTURE UNDER VARIOUS BLAST CONDITION

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Abstract : The main aim of this paper is design and implement Critical Analysis on Performance of RCC Structure Under Various Blast Condition. Advance in technology over the past few decades have necessitated the dynamic effect of loading blast such as wind and earthquake loads. The main purpose of this study is to gain access to materials on blast loads that can be designed, to assess vulnerabilities and to provides guidance to designed to economically reduce the impact of explosion on building and provide protection to human and infrastructure. A case study is performed on an RC column subject to blast loading; the effect of force on the deflection over time, the stress rate on the tensile is studies. The compression mechanism is studies by following the alternative path method for minimum design load for building and other structures. The 2-storey building is analyzed and the displacement and blast loading and standoff distance on the floor vehicles are studied by adding X-type brackets and shear wall to make them explosion resistant. Structural, architectural and managerial aspects of the design are also included in the report so that the structures become blast resistant.

Keywords - Blast Loading, Standoff Distance, Ductility, Collapse Mechanism, Aspects of Design

I. INTRODUCTION

Explosion loading was not so important in earlier eras. Advance in technology have led to increase terrorist activity over the past few decades, highlighting the importance of taking dynamic effect of explosion loading into structure such as winds and earthquakes. Attacks are exceptional cases, man-made disasters and the likelihood of events occurring cannot be accurately determined. Nor can terrorist acts be stopped. Terrorists use new chemicals and technologies, which pose a serious threat to life as well as property. Regarding the safety of life property, explosion resistant designs were brought to light. Designing a fully explosion-proof structure is neither economical nor realistic. However; various strategies can be followed from the planning stage with the advancement of knowledge of current engineering and architecture. The impact of large explosion can be greatly reduced in new structures and even in existing structure.

The main objectives of this study are to access materials on explosion loads that can be subjected to the structure, to assess insecurity, to guide the designer in an economical way to reduce the impact of explosions on buildings and to provide protection to human and infrastructure. Program

1.1 Explosive Type And Explosion

Some of the chemical explosives are TNT, TATP, RDX, PETN and Azirozide Azide etc. Among them TNT is the most commonly used explosive chemical which is very easy and convenient to handle. The complete form of TNT is try nitrate-toluene. It is transmitted as a benchmark, where all other explosives are expressed as equivalent masses of TNT, and the most common method of similarity is the specific energy ratio of the explosive to the specific energy of the TNT.

There are mainly three types of explosions, namely unconfined explosive, limit explosives and explosions caused by explosives attached to the explosion structure. Incomplete explosion is caused by air blowing or surface cracking. When air explodes, the explosives explode above ground level. The immediate amplification of the shock wave is due to the reflection of the ground; Before the initial blast wave of the building. As the waves continue to spread outwards on the surface of the ground, a front is formed known as the match stem; By the interaction of the initial waves and the reflected waves.

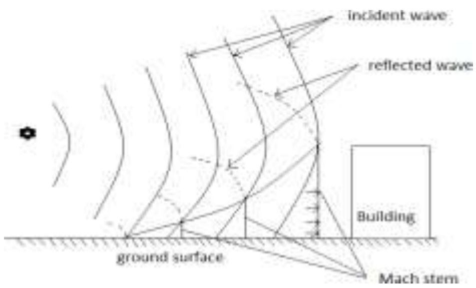


Fig 1: Air burst

When the terrain is very close to or close to the surface, the surface cracks. The initial shock waves are reflected and extend through the ground surface, creating reflective waves. Unlike when an air blast occurs, the reflected wave merges into the incident wave at the site of the explosion; Resulting in a single wave. In most cases of terrorist acts, the built-in area, the equipment is placed on or near the ground surface.

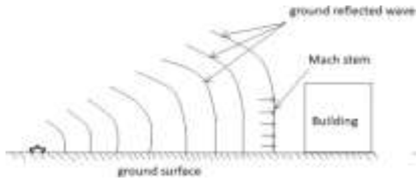


Fig 2: Surface burst

When an explosion occurs in a building, the pressure created by the initial shock front will be high and as a result; The reflection will be enhanced in the building. This type of explosion is commonly known as a limited explosion. In addition, depending on the extent of the limitation, the effect of high temperature, the accumulation of gas product due to chemical reaction at the time of explosion will create additional pressure, which will increase the duration of the load in the structure. Based on extent of vent, various types of confined explosion may take place as show fig.2

Fig 3: Type of explosion

If the explosive is attached to a structural member such as columns, it will create immediate stress, as shock waves will come to the surface and destroy the resulting material. In addition, if an explosion occurs in the structure, the effect will be similar to that of limited and incomplete explosions.

1.2 Shock Waves

An explosion occurs when a gas, liquid, or solid rapidly undergoes a chemical reaction and produces very high temperatures and pressures near the source. Explosions result in the formation of shock waves; Travels outward at extremely high speeds in all directions from the point of explosion and creates explosion waves; Reflect on any object. As the gases move, so does the air. The compressed air passage of the blast wave damages the structure. As the waves move away from the source, the intensity of the waves decreases and so does the effect on the object. However; If there is a closed road like a tunnel, the blast wave travels less and less.

The surrounding area is subject to different types of loading due to the effect of the explosion, which can be grouped under three heads; As a result of the compression of the surrounding air, the air is known as a shock wave. The chemical reaction of explosions causes the accumulation of gases to cause air pressure and air movement, which is known as dynamic pressure. The effects that cause the ground to shrink rapidly are called ground shock waves.

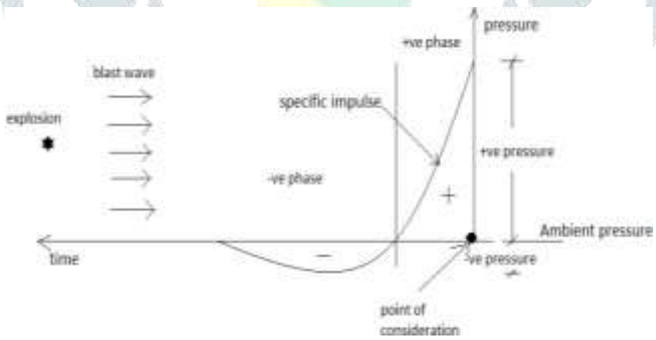


Fig .4: Shock waves created by blast

Air shock waves cause an immediate increase in pressure above the atmospheric pressure at the point of consideration, some distance from the source, Which is generally known to be higher than the pressure. As a result, different pressures are created between the atmosphere and the air, Which is known as negative pressure. When air returns to its original state equilibrium.

Approximately 1 kg of explosives produces approximately $1m3$ gases and the gas displaces and damages nearby air and objects by external expansion. The effects of dynamic pressure are rapidly diminishing as we move away from the source.

The ground shock wave consists of three main components, the wave travels radioly from a source known as the compression wave; The waves travel radially and the particles move in the radial direction in the normal plane; Where the shock wave intersects with the surface, known as shear waves and surface or relay waves; These waves propagate with different speeds and frequencies.

II. **LITERATURE REVIEW**

1. PROTECTIVE DESIGN OF CONCRETE BUILDINGS UNDER BLAST LOADING; STRUCTURES UNDER SHOCK AND IMPACT VII, 2002

Author name: Ali Mir M

Terrorist evidence investigated several issues of the building. He fulfilled the design recommendation for RCC design as per TM-5-1300; Accordingly the concrete casing on both sides of the member is effective in resisting explosions, even if the concrete was crushed, but the steel should be intact so as not to destroy the entire structure. Similarly, concrete strength greater than 400 psi (28 MPa), steel of grade 60, ASTMA A should be used, total size should be limited to 1 inch (25.4 mm), slab reinforcement should be in both directions and reinforcement should be continuous in any direction. In his work, he also included a case study in the well-known Blast. Murray Federal Building, Oklahoma City, USA, 1996. The Federal Emergency Management Agency (FEMA) investigated the incident and insisted that the transfer girder should be avoided on the lower floor, where the third floor of the building was supporting the transfer girder above and three columns. Below are the columns, causing half of the building to collapse. There were also normal moments of resistance in the frame and if a resistive frame was created at a particular moment If used, the loss can be reduced by 50 to 80%. Second, Riyadh, Saudi Arabia, and Amjad monitored the structural reactions of the building during the missile attacks during the Gulf War, and mainly gave the structure a two- to five-story RC frame. Buildings Were designed for normal and wind loading, and the damage to buildings was similar to that caused by earthquakes. They studied explosion loading, standoff distance, incidence, and pressure reflection. The bomber struck shortly after noon in front of a Saudi military base. He summarized the results of recent research conducted on concrete slabs, subject to high dynamic loading; And the dynamic final load capacity was found to be 22-27% higher than the final static load capacity.

2. DETERMINATION OF BLAST LOAD PARAMETERS FOR 2D FRAMED OVER THE FAÃ§ADE OF STRUCTURE(2)

Author name: B. Murali Krishna, Dr. V. Sowjanya Vani

The analysed (G+14) floor building has been constructed with a floor height of m m, a total height of 522 m; Which detects the linear dynamic response of a 2-D building. Various parameters such as measured ground distance, peak positive event pressure, reflective pressure, shock front velocity are measured. Load pressure is determined analytically by the analysis of history; TM-5 is analysed by 1300. Graphs of peak impulse pressure VS time are obtained for each floor. The results show that the distribution of the reflected pressure decreases with height 0.

3. STRUCTURAL ANALYSIS OF BLAST RESISTANT STRUCTURES(1)

Author name: Demin George, Varnitha M.S.

Analyzed that the 2 storey building was completed using ETAB. Here 4 cases are considered with different types of explosive and standoff spacing .. Also 4 models are considered as normal frame, normal frame with cross section between beam and column, common frame connecting shear wall and X-type braking. The load is calculated according to IS-4991-1968, the pressure on the building, the load on the front face, the roof and the side walls are fixed. The effect of the model with shear wall and X-type braking will be reduced by 95% to 80% in maximum floor displacement, respectively. Increasing the size of the beam and column will also improve the resistance, but also due to the serviceability issue of the huge cross section; This is not feasible. The shear wall thus found is also more economical and convenient.

4. NON-LINEAR RESPONSE OF REINFORCED CONCRETE CONTAINMENT STRUCTURE UNDER BLAST LOADING(8)

Author name: A.K. Pandey etc.

Studied the effects of external explosions on the outer reinforced concrete shell of a typical detached container structure. The linear content that is not suitable for the final stage has been analyzed using the model. The analytical process for nonlinear analysis has been implemented in the finite component code by adopting the above model dynamic.

5. BLAST LOADED STIFFENED PLATES(7)

Author name: A. Khadid et al.

To determine the dynamic reaction of plates with different stiffener configurations, fully determined rigid plates under the influence of blast loads were studied to consider the effect of mesh density, time duration, and strain rate sensitivity. To obtain numerical solutions they used the finite component method and the central differential method to combine the nonlinear equations of motion.

III. CASE STUDY

3.1 RC Column Subjected to Blast Loading: RC column of ground floor of height 6.4m of a multi-storied building is analysed in this case. Parameters considered for study are-Strength- 40MPa for NSC (Normal Strength Concrete)

- 80MPa for HSC (High Strength Concrete).
- 80MPa for HSC (High Strength Concrete).
- Spacing of stirrups- 400mm for OMRF (Ordinary moment Resisting Frame).
- 100mm for SMRF (Special Moment Resisting Frame).

It has been found that the size of the column can be effectively reduced by increasing the compressive strength of the concrete. The size column for NSC (500 × 900) mm can be reduced to (350 × 750) mm for HSC with the same axial load carrying capacity.

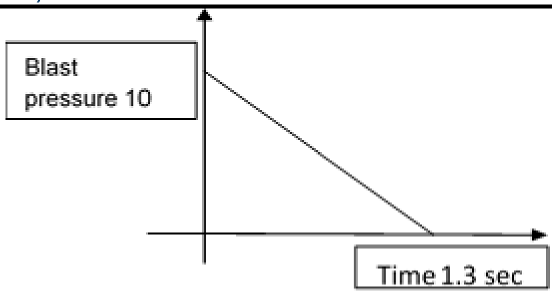


Fig.5 Blast loading

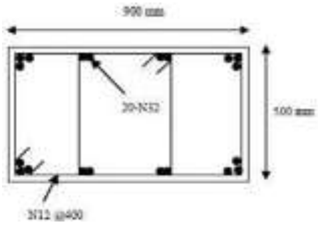


Fig.6 C/S of NSC column-ordinary detaling with 400 mm spacing

Column	Sizes (mm)	f_c (MPa)	Stirrup spacing
NSC	500×900	40	400mm and 100mm
HSC	350×750	80	400mm and 100mm

The 3-D column was analysed using the nonlinear clear code LS-Diana 3D (2002), regardless of the line of both the material and the geometry. The result of blast loading is dynamically analysed to obtain the deflection time history in the column.

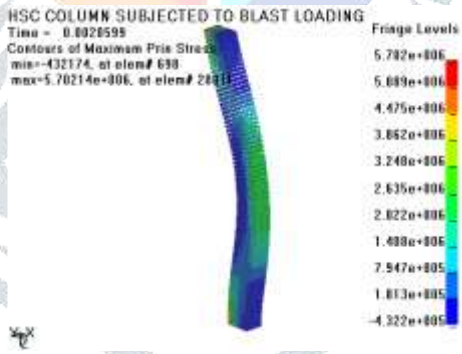


Fig.7 Model of the column using explicit code LS-Dyna3D

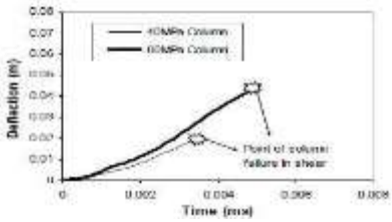


Fig 8: Lateral deflection with time at mid-point of column with 400 mm spacing of stirrup (OMRF)

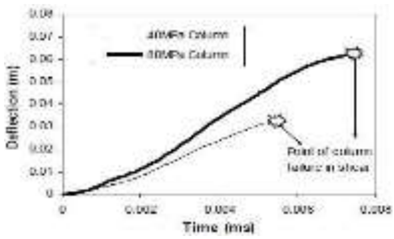


Fig 9: Lateral deflection with time at mid-point of column with 100 mm spacing of stirrup (SMRF)

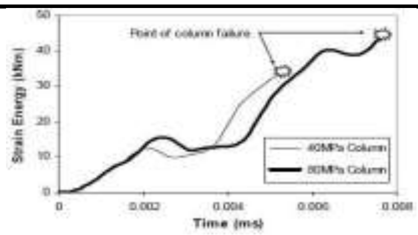


Fig 10: Comparison of energy absorption capacities with 100mm stirrup spacing.

The lateral deflection of the column at the center height of the column with time is shown graphically. (Fig.8 and Fig.9) for both NSC and HSC columns which show lateral resistance in the column. This shows that both NSC and HSC fail due to shear due to near standoff distance. However, the HSC column with low cross section shows better energy absorption capacity than the 40 MPa column of NSC, with a high lateral deflection of 80 MPa. From Fig. 8 and fig. 9, it is clear that the shear reinforcement effect is also significant. Ultimate end-side displacements failing for HSC columns increase from stir 45mm to 63mm 40mm 100mm respectively; Which are 20mm to 32 mm for the NSC with stirrup spacing 400mm and 100mm respectively.

3.2. EFFECT OF STRAIN-RATE ON DUCTILITY

It is clear that increasing the loading rate will increase the strength and stiffness of the concrete, increase the productivity of the steel and also increase the load-bearing capacity of the flexible member. Parametric studies are performed to investigate the effect of high stress-rates on the durability of reinforced concrete members and their elasticity and shear capacity.

Column	400mm spacing	100mm spacing
NSC	12.0 kNm	33.9 kNm
HSC	27.6 kNm	43.5 kNm

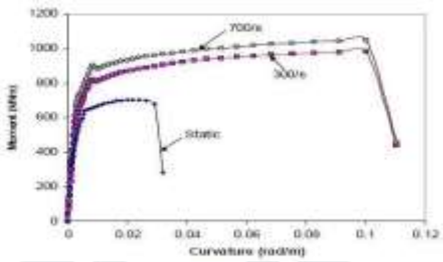


Fig 11: M-Ø curve of a cross-section of a column at different strain rates

Fig. 11 shows the M-Ø relationship from which it is clear that, at high stress rates, the productivity and compressive strength of concrete also increase the elastic capacity and the density of the reinforced concrete beam. The shear capacity of the column is measured using modified compression field theory.

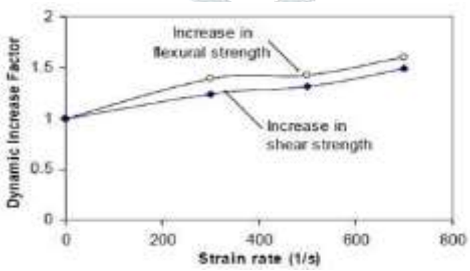


Fig 12: DIFs for flexural strength and shear strength of a column at different strain rates

Fig. Above. 12 shows, at higher stress rates, the increasing proportion of elastic capacity (MUDIN / MUSTATE) and shear capacity (WUDIN / WUSTATE) is compared to the capacities under constant loading. It has also been found that the increase in elastic strength is greater than the increase in shear strength; What shows an increase in physical strength in the dynamic state can lead to brittle shear failure rather than ductile elastic failure.

3.3 PROGRESSIVE COLLAPSE ANALYSIS

Following the collapse of the 22-story Ronan Point apartment building, design recommendations for progressive collapse analysis have been applied to British standards since 1968. Since then, several European countries, the USA and Canada have included progressive collapse provisions in their building codes. The American National Standards Institute (ANSI) Standard A 88.1-1-1982, "Minimum Design Loads for Buildings and Other Structures," recommends an alternative route that allows local failure but provides alternative routes around the failed person. Is required. Creative members.

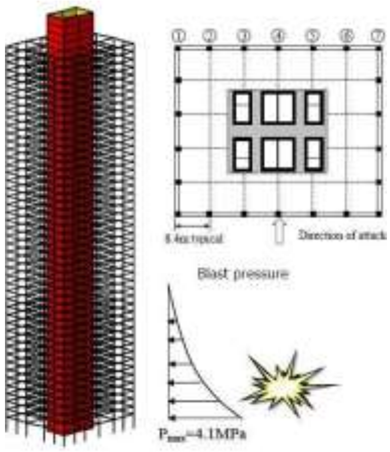


Fig12: structural configuration

The modified type of typical building in Australia is a 52-story high 3. . The plan and structural configuration of the building are shown in Fig. 12. The distance between the columns is 8.4 m / c in circumference, which are connected by spindle beams to support the front face support. The lateral load is resisted by a 6 core box in the center of the scheme. The building is designed to withstand background loads due to wind and seismic loading as specified in the Australian Loading Standards AS1170.2 and AS1170.4. Slabs, columns and core walls are laid on site. Background load resistance is provided by the Lateral Load Resistance System (LLRS) of the core walls, which is about 80% of the total capacity.85-storey building, analyzed in this study.

Here, the local damage caused by ground-level bombings and the progressive collapse of the building is studied. Structural stability and integrity of the building are evaluated, taking into account the consequences of failure of floor slabs due to perimeter, spindle beams and floor over-pressure. The main purpose of this analysis is to examine whether the failure of any primary structural member can lead to a progressive collapse, which can propagate at the floor level to the vertical or next vertical structural member above or below the affected member.

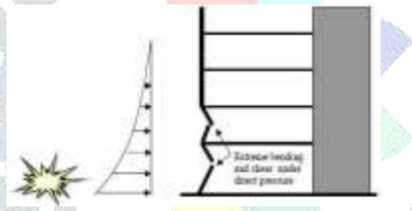


Fig 13: direct column loading

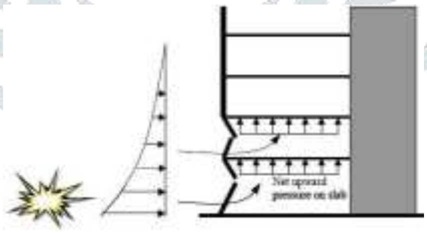


Fig 14: uplifting of floor slab

Fig. 13 and 14 show the effect of explosion pressure on columns and beams on the perimeter of the building on the perimeter and floor slabs. The thickness of the building slab is 125 mm, supported by pre-stressed wide band beams. The direct explosion of the part of the slab near the blast occurred at high pressure. Normal glazing in the fade of a building provides negligible resistance to blast waves. As a result, after the failure of the glazing system, the blast fills the structural bay above and below each floor slab. The explosion below the slab causes the pressure to be higher than the pressure above it and this causes a net upward load on each slab.

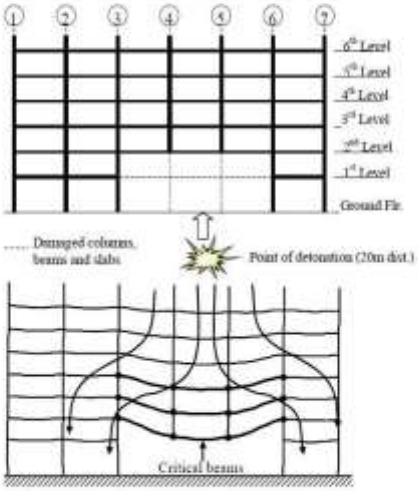


Fig15: progressive collapse analysis of the perimeter frame, caused by blast loading

To detect local damage, explosion analysis is performed on the beam, and columns on the perimeter of the building and floor slabs, under the pressure of the actual explosion on each component. In Fig. 15, the results are plotted, showing the failure of column levels 4, 5 and 5 floors due to the direct effect of the blast wave. Also the slabs and beams in column lines 3 to 6 collapsed. The Member Assessment (RESPONSE) (2001) program was based on the improved compression field theory and LSDYNA. It also shows that, if the reinforcement details are in accordance with the requirements of the Special Moment Resisting Frame (SMRF), the shear capacity and shrinkage will be significantly improved, which will improve the explosion and impact resistance of the member. In the damaged model of the perimeter frame, the failed components were removed and re-analyzed for re-examination.

Fig. 16 shows the alternate load paths, which pass through the columns surrounding the damaged area, from which the vertical load is transferred. The failure of the auxiliary columns makes the beams and floor slabs in that area critical. The overall stability of a structure depends on the continuity and durability of these components that redistribute forces in the structure. Falling debris, collapsed members also impose heavy loading on the floors below, and thus it is necessary to check whether the overload can be carried forward without further collapse.

IV. OBJECTIVE

1. The main objective of the study is to minimize the impact of building explosions in an economic way to protect human and infrastructure from multiple extreme events.
2. Study and analysis of the effect of different explosives on the structure considering the weight and different distances
3. The purpose of blast proof building design is to prevent complete collapse and damage to the building.
4. Improvements in the process of structural design to increase safety from the effects of explosives and against techniques in design.
5. To study the managerial aspects of structural, architectural and structural design structure.
6. To study the use of software in designing.

V.DESIGN METHODOLOGY OF BLAST RESISTING STRUCTURE

5.1 Methodology:

A two-story structure with 100 kg and 300 kg weight explosives (TNT) is studied at different standoff distances of 20 m and 100 m. Blast loading parameters are calculated according to IS4991-1968 (Reformed 2003) and four different models are created using ETAABS. Dimensional properties of the frame selected for the study:

The length and width of the frame are 3 bays of 3.5 m each and 3 bays of 3.5 m.

The 4 different models are:

1. Structure with normal frame with column and beam size (400 × 400) mm and (300 × 400) mm, respectively.
2. Model 2: structure with normal frame with increased cross section column and beam size (600×600) mm and (400×600) mm respectively.
3. Model 3: model 1 with addition of shear walls of thickness 150mm.
4. Model 4: model 1 with addition of X shaped steel bracing.

The different load cases used for study are:

- Case 1: 100Kg of blast at standoff distance of 30m.
- Case 2: 100Kg of blast at standoff distance of 20m.
- Case 3: 300Kg of blast at standoff distance of 30m.
- Case 4: 300Kg of blast at standoff distance of 20m.

5.2. Load Calculations

Explosive loadings are calculated as per IS4991-1968, and explosive parameters are determined as follows:

As per clause 5.3, scaled distance,

$$\frac{actual\ distance}{W1/3} = \frac{30}{0.1^{1/4}} = 64.65$$

Where w=100Kg=0.1 tonne

From table-1, to determine explosive parameter between distance 63m and 66m

Peak side-on over pressure, Pso=0.35 kg/cm² Peak reflected over pressure, Pro=0.81 kg/cm² Dynamic pressure, qo= 0.042 kg/cm²

Mach no. M= 1.14

The scaled time for the scaled distance 64.65m are obtained multiplied by to 0.1 1⁄3 to the tabulated values of the respective quantities for the actual explosion of .1 ton charge.

Positive phase duration, t = 37.71×0.1 1⁄3= 17.5 milliseconds

Duration of equivalent triangular pulse, td= 28.32×0.1 1⁄3= 13.15 milliseconds

The scaled time for the scaled distance 64.65m are obtained multiplied by to 0.1 1⁄3 to the tabulated values of the respective quantities for the actual explosion of .1 ton charge.

Positive phase duration, t = 37.71×0.1 1⁄3= 17.5 milliseconds

Duration of equivalent triangular pulse, td= 28.32×0.1 1⁄3= 13.15 milliseconds

Shock front velocity, U= M.a = 1.14×344 = 392m/sec =0.392 m/milliseconds

Where a= velocity of sound in air, 344m/sec at mean sea level at 20º C.

5.3 PRESSURES ON THE BUILDING

Here, H =6m, B=10.5m and L=10.5m and S=6m (either H or B/2)

Clearance time, $t_c = \frac{3S}{U} = \frac{3\times6}{0.392} = 45.91$ milliseconds $> t_d$

Travel time of shock from front to rare face, $t_c = \frac{L}{U} = \frac{10.5}{0.392} = 26.7856$ milliseconds $> t_d$

Pressure rise time on back face, $t_r = \frac{4S}{U} = \frac{4\times6}{0.392} = 61.22$ milliseconds $> t_d$

As $t_r > t_d$ no pressure on the back face, are considered.

From table 2, for roof and sides C_d = -0.4 (for $q_o = 0\ to\ 1.8\ kg/cm^2$)

As per cl.6.2.1.1. The net pressure acting on the front face at any time t is the lesser of i. and ii..

i. Reflected pressure P_{ro}= 0.81 kg/cm²

ii. $P_{so} + C_d \times q_o$= 0.35 – (0.4×0.042) = 0.33 kg/cm²

5.3. LOAD ON FRONT FACE JOINTS

Loads on centre joints = 81 kN/m²×3.5×3 = 850.5 KN

Loads on Side joints = 81 kN/m²×3.5×$\frac{3}{2}$ = 425.25 KN

Loads on Edge joints = 81 kN/m²×$\frac{3.5}{2}$×$\frac{3}{2}$ = 212.625 KN

5.5. LOAD ON ROOF AND SIDE WALLS

Loads on Centre joints = 33 KN/ m²×3.5×3 = 346.5KN

Loads on Side joints = 33 KN/ m²×3.5×$\frac{3}{2}$ = 173.25KN

Loads on Edge joints = 33 KN/ m²×$\frac{3.5}{2}$×$\frac{3}{2}$ = 86.625KN

Bracing used for the analysis of the system is ISLC 200Channel section.

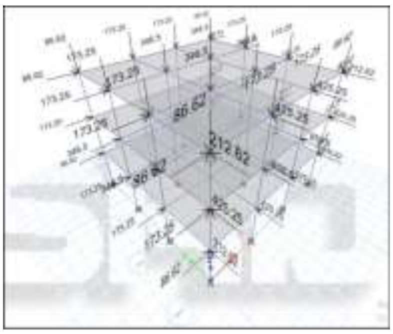


Fig 16: load application for case - 1

5.6. Results And Discussion

The models are generated and analysed by ETAB 2015, and loads are applied based on all the 4 load cases. Live load on floor is taken as 3 kN/mm² as per IS 875 part-2. The structure is analysed by non-linear static analysis as loads are converted to static joint loads.After analysis, result shows for the model 1; the maximum inter storey drifts are 54.3 mm, 21.4 mm for 300 Kg blast load from 30 m and 20 m standoff distance; and the max storey drifts are 10.5 mm,24 mm for 100kg blast load from 30 m and 20 m standoff distance. But as per IS 1893 maximum allowable storey drift is 12 mm (0.004×storey height). Thus, maximum storey drift are not satisfying IS code recommendation in model 1.

In this model 2 for all the load cases, the cross-section of beams and column are increase compare to model 1, are maximum storey displacement and the maximum storey drift reduced by around 70%and 65% respectively.

The Distorted shapes of the 4 models in case 1 is shown below

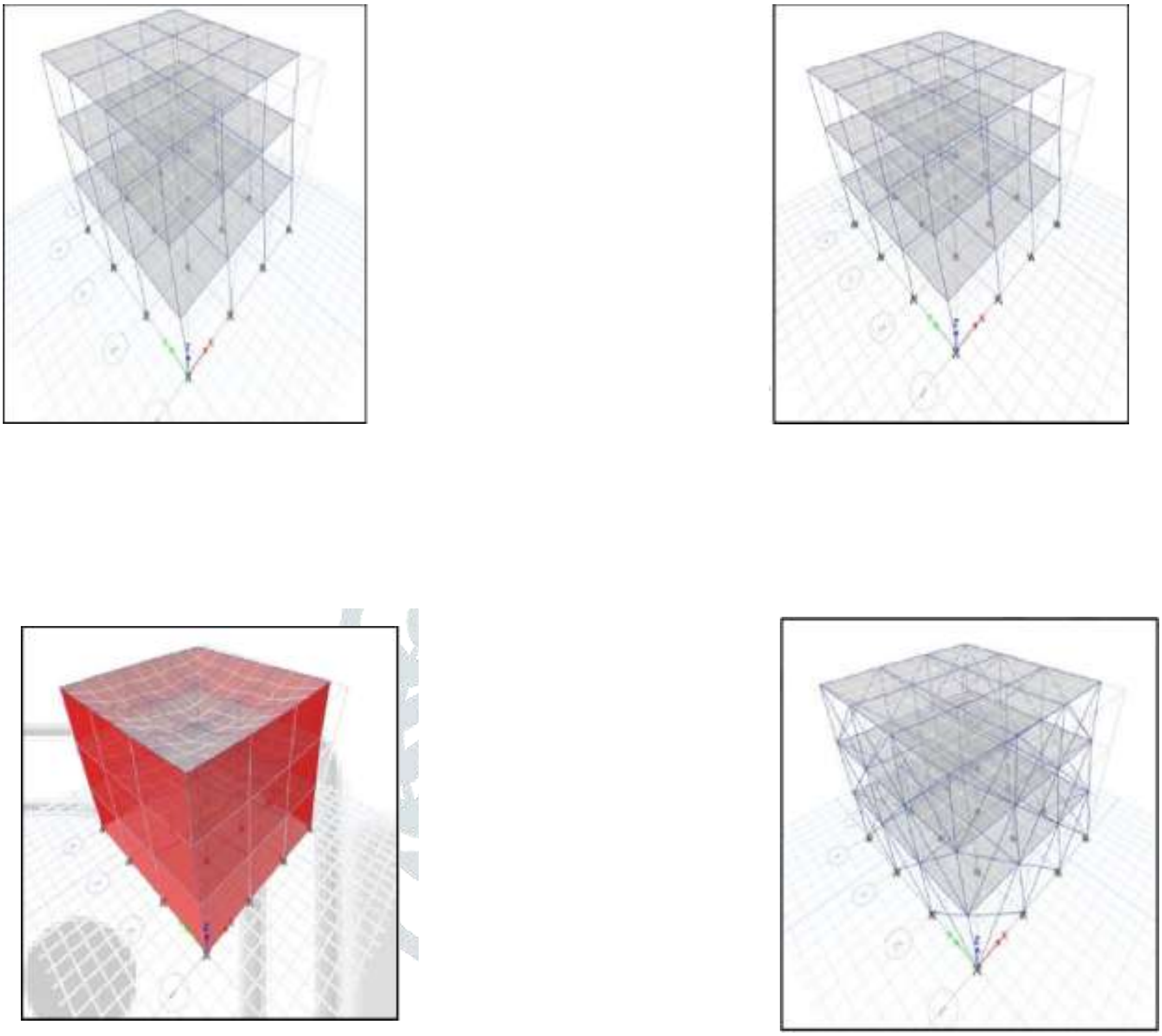


Fig 17: Distorted of mode 1, 2, 3 and 4 respectively

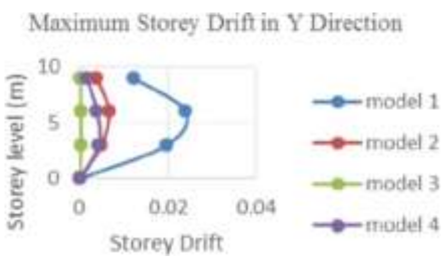


Fig 17: Maximum floors drift in case 1

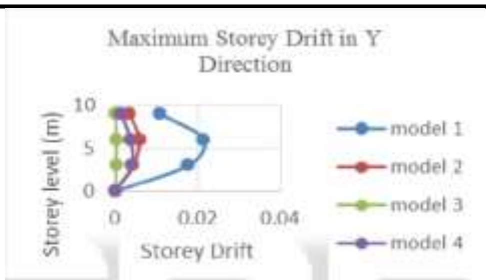


Fig 18: Maximum floors drift in case - 2

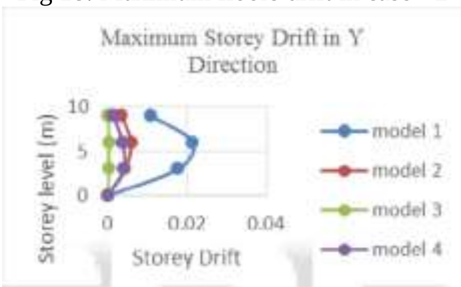


Fig 19: Maximum floors drift in case – 3

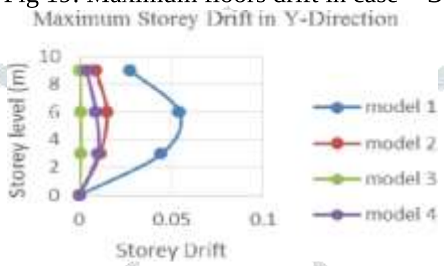


Fig 20: Maximum floors drift in case – 4

Floor displacements and floor vehicles are shown in the X direction, as the floor displacement and floor carrying in the Y direction is very low and within permissible limits.

In Model 3, the addition of shear walls around the structure in Model 1 reduces the maximum floor displacement and maximum floor carrying by about 95% compared to the model.

• In this model the shear wall has been found to be effective in reducing floor displacement; Maximum displacement and maximum story carrying within the allowable limits as per IS 1893.

In the Model 4 In, the addition of steel braking around the structure helps to reduce the maximum floor displacement and the maximum floor displacement and the maximum floor shearing compared to the floor shearing of the Model 1.

5.7 CONCLUSIONS AND RECOMMENDATIONS: THE FOLLOWING POINTS CAN BE DRAWN FROM THE RESULTS OBTAINED FROM THE ANALYSIS

A. As the blast loading increases and the standoff distance decreases, more and more displacement and stories are carried. Blast parameters depend on blast load and standoff distance. Thus the design response depends on the blast load and the standoff distance.
B. By increasing the size of the beams and columns, the resistance of the structure can be improved, but is practical from the service point of view of the structure; This is because the serviceability limit cannot be met by the huge cross section of beams and columns.
C. Adding shear wall and X type steel bracket effectively resists explosion load. The use of steel braking around the structure gives good results; But shear wall gives more desirable results than steel brackets and it is also economical.

VI. STRUCTURAL, ARCHITECTURAL AND MANAGERIAL ASPECTS OF BLAST RESISTING

DESIGN OF STRUCTURE

The front face of the building experiences peak overpressure created by the blast waves and decides to be zero as the ripples of the initial blast go over the reflective surface of the building. The front face feels the comfortable effect of the blast; The sides and upper faces of the building are exposed to excessive pressure. When the blast wave does not travel the length of the structure and there is no pressure on the rear of the structure until a compression wave starts to move to the center of the rear face. There will be a time in the development of pressures and loads on the front and rear faces, as the translating forces work on the building in the direction of the blast wave. Therefore, the created pressure is not instantaneous.

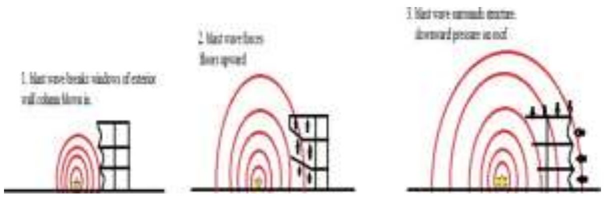


Fig 21: Sequence of air-blast effects

Although blast loading are additional common load cases, their impact should be adequately considered during structural design. The dynamic design of explosion-resistant structural design as a static design also uses compact limit design and serviceability limit design. The goal of the design is to provide adequate dilution to prevent the building from collapsing completely. If an explosion occurs, significant translational movements and moments will occur and the load must be transferred from the beam to the columns. The structure does not collapse after the explosion but it can no longer function.

However, according to the design of the serviceability limit the building should function properly after the explosion. Only non-structural members such as windows or cladding may require maintenance after an explosion, so that their structure should be adequately deutile.

The type of blast loading, in which the positive phase of the shock wave is less than the natural vibration period of the structure, is defined as "impulse loading". Here, before the composition responds, the blast effect disappears. This type of blast loading is defined as "semi-static loading" when the positive phase exceeds the natural vibration period of the structure. In such a situation when there is maximum deformation of the structure the load can be assumed to be constant. This is the function of maximum deformation blast loading and structural rigidity. If the duration of the positive phase is the same as the natural vibration period of the structure, the behavior of the structure becomes much more complex which can be defined as “dynamic loading”.

Common building frames designed to resist gravity, wind loads and earthquake loads have been found to be deficient in two respects. Beam-to-column connections can be brought under extremely high force in an explosion. These forces will consist of horizontal elements arising from the walls of the building and vertical elements from differential loading on the upper and lower surfaces of the floor. Providing additional strength to this connection can be significantly enhanced.

In connection, general details for static loading are found to be insufficient for blast loading. Especially for steelwork beam-to-column connections, the connection must withstand unstable deformations so that the moment frames can function even immediately after an explosion. Figure 31 shows the side-plate connection. The main feature is that additional links are used in reinforced concrete connections, which are used to reduce the risk of breakage or to damage the connection, possibly resulting in a reversal of the load on the beam. In critical areas, complete moment-resistant connections are made to ensure the load-bearing capacity of the structural members after an explosion. Beam works primarily in the beam can also apply significant axial load during explosion.

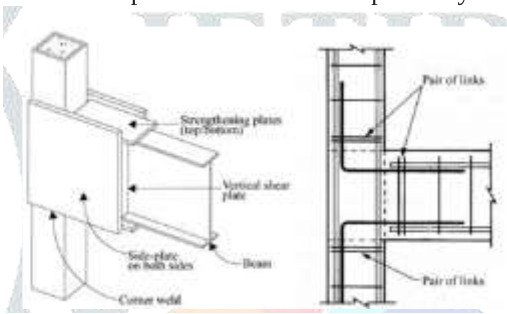


Fig 22: Beam-to-column connection details

Typically columns are designed for axial loads that can take arrows in case of an explosion; This can reduce the load carrying capacity of a department. Columns of reinforced concrete structures are the most important members that should be protected in the event of an explosion. Two types of wrapping can be used in this case; Wrap with steel belt or wrap with carbon fiber-reinforced polymer (CFRP).

Cast-in-situ reinforced concrete floor slabs are preferred for explosion resistant buildings, but in some situations precast floors can also be used. It is not recommended to use a precast floor unit on the first floor as the risk of internal explosion is highest. Especially light roofs, glass roofs should be avoided and a reinforced concrete or precast concrete slab should be preferred**.**

6.1. Architectural aspects

The goal of explosion resistant design is to minimize structural damage in the event of an explosion. The primary requirement is to prevent catastrophic failure of the entire structure or large parts of it. It is also necessary to minimize and minimize the effects of infectious explosion waves in the building through the opening.

6.2.1. Planning and layout

From the planning phase of the new building; Potential hazards and risks associated with injury and damage can be minimized. Immediate terrorist attacks require explosion protection for structural and non-structural members, as well as adequate space for shelters in the building. To minimize external hazards, external bombs and vertical spaces in buildings must be increased as much as possible. This can be achieved through barriers such as bollards, trees and street furniture in places like the city area. Figure 23 shows the possible external layout for blast safe planning.

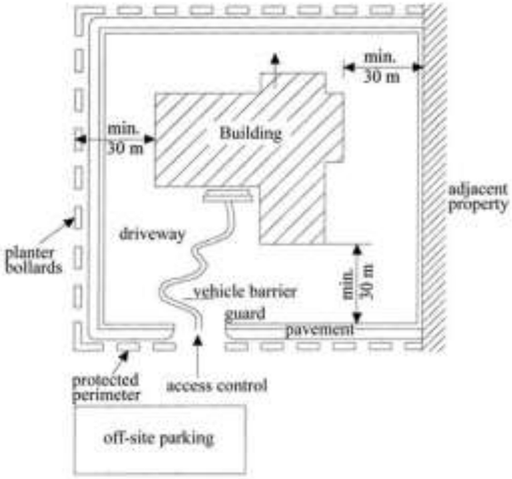
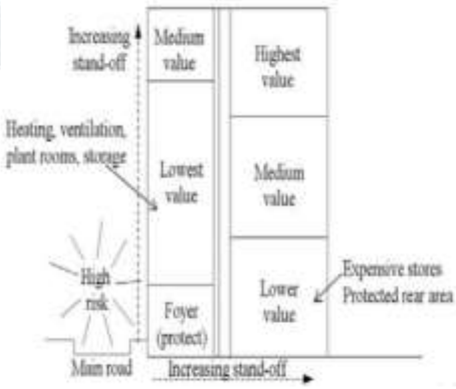


Fig 23: Layout of site for protection against bombs

6.2.2. Structural form and internal layout

The structural form is affected by the load of the blast. Structural forms such as arches and domes have less blasting effects than cubic forms. The layout of the building also has a significant effect on the magnitude of the blast load, over which the building is occupied. The complex shape causes many reflections of the blast wave and should therefore be avoided. Projecting roofs or floors and U-shaped buildings are undesirable for this purpose. It should be noted that single story buildings are more explosion resistant than multistory buildings. Partially or fully embedded buildings are explosion resistant, as such structures take advantage of the shock absorbing properties of the surrounding soil. Provides soil protection in the event of a split explosion.

The internal layout of the building should be arranged so that the high external hazard will be separated by the largest distance from the property. Foyer parts should be protected by reinforced concrete walls; Double-doors must be used to prevent explosion pressure inside the building, and the doors must be fitted in a corrugated manner within a corridor. The entrance to the building should be controlled and separated from other parts of the building by strong construction for maximum physical protection. Parking under the building or underpass of the building or car should be avoided unless access is controlled. Internal members should be designed to withstand fire, as an explosion can cause a fire, which will increase the damage in a disaster.



6.2.3. Bomb shelter area:

Bomb shelters are specifically designated inside buildings where there is less vulnerability to the effects of explosions and what personnel can withdraw if a bomb occurs. Reasonable protection against explosions is required in these areas; It should be large enough to accommodate employees and have enough space to facilitate continuous access. In the case of modern-framed buildings, the shelter area should be located away from windows, exterior doors, exterior walls and upstairs. Net areas can be strictly walled and surrounding areas such as underground car parks, gas storage tanks, light weight partition walls, internal corridors, toilet areas or conferences.The building will not collapse even after making sure that the basement can sometimes be a useful shelter area.
The functional aspect of the bomb shelter area is to accommodate all the occupants of the building; Providing adequate communication from the outside; Adequate ventilation and cleanliness.

6.2.4. Installation:

Gas, water and electrical connections, steam installations, lifts and water storage systems should be planned to withstand any impact of the explosion. Installation connections are a serious issue to consider and avoid using in high-risk deformation areas. Electrical and other installations should be avoided in areas such as exterior walls, ceilings, roof slabs, car parking spaces and lobbies. The main control units and installation feeding points should be protected from direct attacks and a reserved installation mechanism should be provided to prevent possible explosions and should be located away from the mail installation system.

6.2.5. Glazing and cladding:

Broken windows and windows may be responsible for the massive injuries in the blast in the city center. Choosing a safe glazing material is critical and it has been found that laminated glass is the most effective in this aspect. On the other hand, using transparent polyester anti-shatter film on the inner surface of the glazing is also an effective method. For cladding, several designs

Aspects should be considered to reduce the insecurity of the people in the building and the damage to the building. The amount of glazing in the facade of the building should be minimized, which will limit the amount of internal damage from glazing and the amount of explosions that can penetrate. The cladding should be fixed to the structure with easily accessible fixing and this will allow for a quick inspection of any failure or movement.

6.3. Managerial aspect

Risk and risk reduction process:

The risk to the property is the net negative impact. The value of the property and the insecurity of the property can be represented

Risk = p {risk × value × insecurity}

The concept of risk management is related to the aspect that is indicated for the probability of the occurrence of an unwanted occurrence and is generally related to terrorist threats.

Whether the building is new or existing, the risk reduction process involves the following steps as shown in Fig.25

Fig 25: Steps involved in risk reduction process

Step 1: Identify threats and ratings include identifying threats; Gathering information; Determining the design base risk and determining the threat rating.

Step 2: Asset valuation involves identifying potential layers of protection; Identification of critical assets; Identifying building core functions and infrastructure; And determine the asset value rating.

Step 3: Insecurity assessment involves organizing resources to create an assessment; Evaluate the site and building; Creating an insecure portfolio; And determining insecurity ratings.

Step 4: In the risk assessment process; The risk assessment chart is prepared, the risk rating is determined and the components in the building are prioritized.

Step 5: mitigation options Identify the primary mitigation options; Review of mitigation options based on cost estimates; Reviewing levels of mitigation, cost and protection. Clearly, the process of risk mitigation is holistic and requires a holistic approach. Each of the steps and functions listed are useful in the design of terrorist resistors.

VII . Future Scope

To detect local damage, explosion analysis is performed on the beam, and columns on the perimeter of the building and floor slabs, under the pressure of the actual explosion on each component. In Fig. 15, the results are plotted, showing the failure of column levels 4, 5 and 5 floors due to the direct effect of the blast wave. Also the slabs and beams in column lines 3 to 6 collapsed. The Member Assessment (RESPONSE) (2001) program was based on the improved compression field theory and LSDYNA. It also shows that, if the reinforcement details are in accordance with the requirements of the Special Moment Resisting Frame (SMRF), the shear capacity and shrinkage will be significantly improved, which will improve the explosion and impact resistance of the member. In the damaged model of the perimeter frame, the failed components were removed and re-analyzed for re-examination.

Fig. 16 shows the alternate load paths, which pass through the columns surrounding the damaged area, from which the vertical load is transferred. The failure of the auxiliary columns makes the beams and floor slabs in that area critical. The overall stability of a structure depends on the continuity and durability of these components that redistribute forces in the structure. Falling debris, collapsed members also impose heavy loading on the floors below, and thus it is necessary to check whether the overload can be carried forward without further collapse.

VIII. CONCLUSION

Blast result in 'air bursts' when an explosion occurs and 'surface bursts' when an explosion occurs near the ground. Due to the number of terrorist attacks, many investigators conducted extensive research. The advancement of technology has increased day by day; In which the effect of blast waves, modelling and analysis of RCC structure is done and design considerations are discussed. This report studies case studies in RC columns subject to blast loading, considered for NSC and HSC studies, showing both the deflection and energy absorption of concrete; Which shows that both NSC and HSC fail due to shear due to near standoff distance. However, HSC columns of power with a lower cross section have higher lateral deflection, indicating better energy absorption capacity than columns of NSC, the effect of shear reinforcement is studied.

The study is conducted to study the effect of high stress-rate on the durability of reinforced concrete members and their elasticity and shear capacity. It is clear from the M-Ø relationship that, at higher stress rates, as the productivity and compressive strength of concrete increases, the elastic capacity and shrinkage of reinforced concrete beams increase; And also indicates whether the increase in elastic strength is greater than the increase in shear strength; Which leads to an increase in physical strength in the kinetic state resulting in increased brittle shear rather than dutile flexural failure.

A 52-story building is considered to study the progressive collapse mechanism. Considering the impact of ground level bomb blasts and local level blast beams and floor slab level failures, spatial analysis of the building's pile to and the building's progressive fallen component is analysed. The stability and integrity of the building is assessed, to verify that the failure of any primary structural member will lead to a progressive collapse, which may propagate to a floor level, above or below the affected member vertically or to the next vertical structural member. If the reinforcement details as required by the special moment resisting frame (SMRF), then the shear capacity and durability will be significantly improved, which will improve the member's explosion and impact resistance. "Minimum design load for buildings and other structures", which recommends an alternative route method for studying compression systems, where local failures are allowed, but alternative routes around failed structural members must be provided and surcharges for failed structure design considered as waste mode.

For the study, a 2-storey building with TNT weighing 100 kg and stand-off spacing weighing 300 kg is analysed. Blast loading parameters are calculated and four different models are created using ETAABS, including the common frame with normal cross-section of beta and columns and X braking and shear wall attachment. The effect of standoff distance on blast loading and draft and displacement is studied. The blast load increases and the standoff distance shows the effect of maximizing displacement and decreasing the story-carrying growth. By increasing the size of the beams and columns, the resistance of the structure can be improved, but is practical from the point of view of the serviceability of the structure. Adding shear wall and X type steel bracket Will effectively resist explosion loads. The use of steel braking around the structure gives good results; But the shear wall gives a more desirable result and it is also economical.

The report also covers the structural, architectural and managerial aspects of explosion-resistant design. According to structural requirements, in order to be explosion resistant, all structural members must be durable, so that local failures can occur, but the entire structure cannot fail. For which special attention should be paid to beam column joints. In critical areas, full moment-resistant connections are made to ensure the load-bearing capacity of the structural members after an explosion. Beam works primarily in the beam can also apply significant axial load during explosion. Columns of reinforced concrete structures are the most important members that should be protected in the event of an explosion. Similarly in the case of slabs, cast-in-situ reinforced concrete floor slabs are preferred for explosion resistant buildings, but precast floors can also be used in some situations. Similarly the planning and layout of the building should be done and the structural form and internal layout should be designed in such a way as to minimize the impact of the explosion. To reduce the impact of the explosion, increase the stand-off distance by providing bollards, trees and street furniture. Uniform single-story buildings are more explosion-proof than complex-sized and multi-storey buildings. Bomb Shelter Area b.

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