Analysis and Design of A Reinforced Concrete Building to Resist Explosions

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***Abstract*:- The research dealt with fortified buildings and the materials used in their construction, and the focus was on the destructive factors of the explosion and the types of explosions affecting the building. The explosion load was calculated using special equations, and after determining the loads affecting all the building, they were modeled and analyzed in the structure using the ETABS program. The structural elements were designed manually through using result of the computer analysis. according to the above mentioned abstract, it was noted that with the stability of the charge and the increase in the distance of confrontation between the source and the structure, a building with a greater degree of safety is obtained, that is, the phenomenon of moving away can be adopted as much as possible in protection.**

Keywords:- Explosion, total buildings, destructive factors for the explosion, shock wave, conventional weapons, dynamic loads , TNT.

1-INTRODUCTION

The use of explosive weapons originally intended for open battlefields in countries is still a cause of devastation, as it leads each time to the killing of individuals, severe injuries, or the destruction of facilities such as schools and hospitals. during the first sixty years of the twentieth century; Criteria and methods based on the results of catastrophic events were used to design blast-resistant structures, and these standards and methods did not include a separate or reliable quantitative basis for assessing the degree of protection provided by a protective facility of accidental explosions, in the latest of the 6th century the quantitative assessment was shown in (Structure to resist the effects of accidental explosions, Unified facilities criteria (UFC)[10]

and Hawkins, NM and Mitchell [6] talk about the gradual collapse of flat structures and the response of the structures after the sudden loss of a column. The logical design methods were also described to provide the structural protection required for receiving and transferring loads. These design methods explain the effects of near explosion, including high pressures, and irregular explosion loads on structures or protective barriers in (Structure to resist the effects of accidental explosions, Unified). facilities criteria (UFC) [10])

2- THE IMPORTANCE OF THE RESEARCH

The aim of this research is to throw light and high light on the safety of building against explosion disasters in both architectural and structural design with special concentration on different techniques on such design, by doing so one can minimize and pleasant distractive effect in such design.

3- RESEARCH METHODOLOGY

The general aspects of the detonation process were presented to clarify the explosives effects on buildings, as having a better understanding of explosives and the properties of explosions would enable us to make the design of explosion-proof buildings more efficient. This research is based on the definition of explosions. And their dangers to buildings, fortified structure and the destructive factors of an explosion. Then, the theoretical description of the behavior of the concrete structure exposed to manually calculated explosive loads was studied with special equations based on a known or estimated amount of explosive charge associated with a superficial explosion by a conventional weapon affecting the building. Then loads in the building were modeled and analyzed, the design of the building was carried out according to the American Code to include the safety of individuals, the examination was carried out using the ETABS program, and the deformations and collapses in the building were described. at last many issues related to the design of concrete structures to withstand explosion loads were discussed in this research.

4-EXPERIMENTAL PROGRAM

The explosion is a sudden release of the potential energy in explosive materials that have a high capacity of Gas production under conditions of high pressure and at high speed, as it subjected the surrounding environment to strong and effective dynamic pressure, to understand and know how structures respond to explosive loads, it's so important to know the main explosive factors such as:

- Shock wave.
- High temperature.
- Flying shard.
- Sound wave.

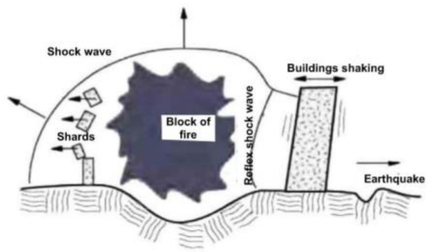

Figure (1) Shows the main effects of the explosion

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The explosion produces waves in the air and the ground, creating shock waves and ground waves. The main damage mechanism of the explosion is a shock wave that propagates radially from the source of the explosion and takes the form of a bubble and its speed is supersonic, and explosion imposes short duration and high intensity stresses on all surfaces in its path. The amount of energy emitted from an explosion is related to the type of explosive device used. Since there are a number of potential sources, it is useful to have a standardize measure by which we can determine the rational threat that could be inflicted on the building. Therefore, trinitrotoluene has become the standard measure of the power of an explosion as conventional explosive methods produce what It is equivalent to from 1 kg to 15 kg of TNT.

Various tests have been performed to translate quantities of explosives into equivalent weights of TNT, usually when comparing explosions using the weighted field principle.

$$Z = \frac{R}{W^{1/3}}$$

Where

R is the distance in meters

W is the equivalent weight of explosive from TNT

The explosion load was calculated for a charge of 50 kg of TNT and for different encountered distances of 10 meters, 20 meters, and 30 meters according to The following four

Confrontation distance M	Pressure KN\m	Joint1		Joint2		Joint3	
		Area M^2	Load KN	Area M^2	Load KN	Area M^2	Load KN
10	413	3	1239	6	2478	12	4956
20	51	3	153	6	306	12	612
30	42	3	126	6	252	12	504

steps:

first step: The measured ground distance from the center of the explosion to the concrete structure was determined, and the weight of the equivalent charge of TNT was determined.

second step: A safety factor of 20% was placed on the weight of the equivalent charge.

third step: The distance traveled on the ground was calculated using the weighted field principle.

fourth step: The parameters of the explosion vector for the free field were determined from Figure (2) for the measured ground distance By the weighted field principle (to obtain the absolute value the measured values are multiplied by $W^{1/3}$)

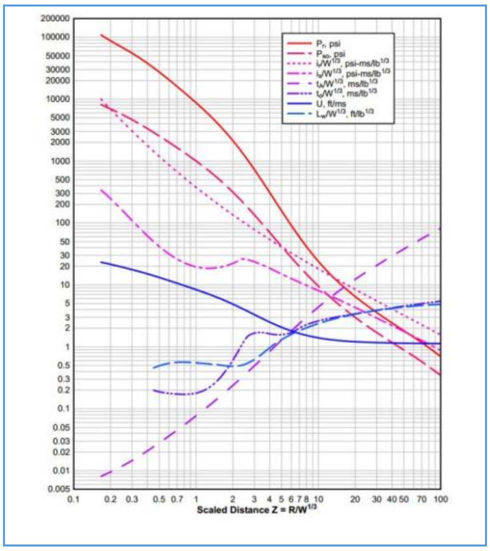

Figure (2)
Positive phase Shock wave parameters for a Hemispherical TNT Explosion on the surface at sea level

The following table puts the approximate values of the maximum explosion pressure resulting from the shock wave, according to the mass of the explosive charge of 50 kg and different distances from the site of the explosion

Confrontation distance M	U Ft/ms	Is psi/ms	To Ms	ta ms
10	1.88	56.1	9.7	11.22
20	1.65	35.7	14.3	45.9
30	1.12	25.5	15.8	61.2

An explosion load was introduced as a Joint load, and the analysis and design process was carried out using the Etabs program as shown in the following figures

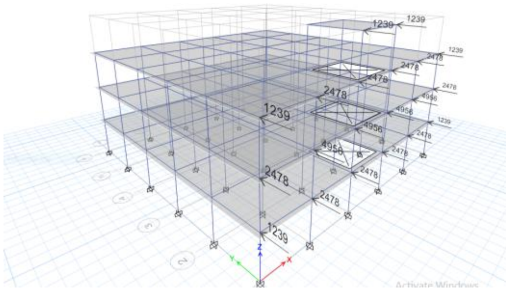

Figure (3) Explosion loads applied to the building with a facing distance of 10 m.

In the executed explosions, large number of columns collapsed as a result of the lateral pressure applied at a distance of 10 m, where 62 out 112 columns collapsed and this collapse seems to be due to over design of steel reinforcement, where in some columns reached (13%) out of the cross-section area column. It should be noted that the maximum percentage of iron allowed in the American Code is (8%), and as for the beams, (70) beams has been destroyed out of (184), shown in the following figure as

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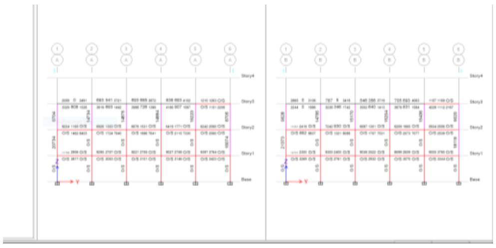


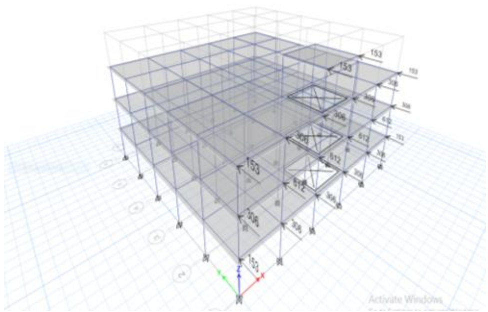


Figure (4) Explosion loads applied to the building with a facing distance of 20 m.

By comparing the results with the results of the previous model, it was found that the building was not affected and no columns collapsed, but it was noted that the amount of reinforcing iron is very large, which makes the building achieve the goal of safety and does not achieve the economic goal.

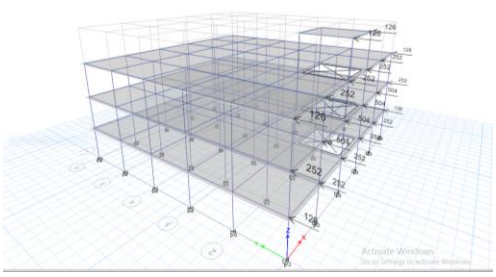
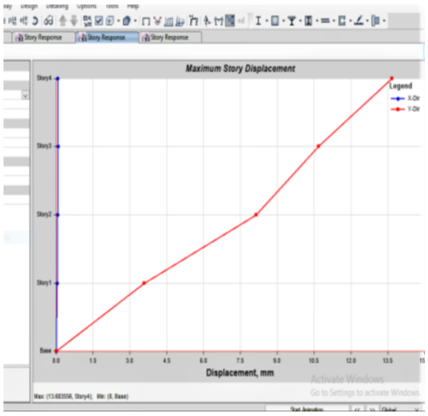


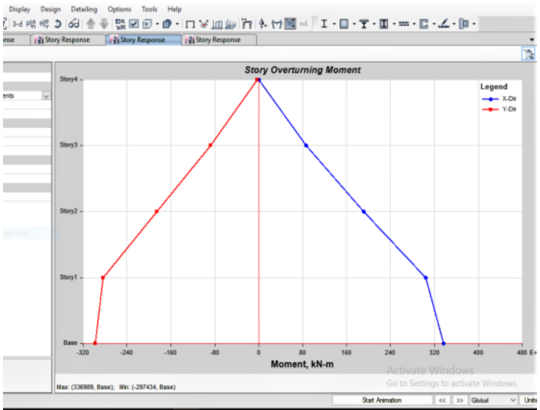
Figure (5)
Explosion loads applied to the building with a facing distance of 30 m.

5-THE RESULTS AND THEIR DISCUSSION

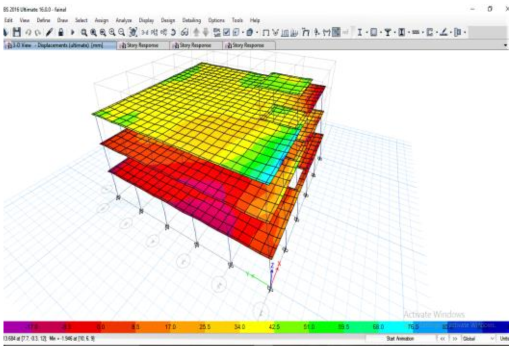
1- It was noted that with the stability of the load (50 kg) and the increase in the confrontation distance between the source and the structure, a building with a greater degree of safety is obtained, so it is possible to adopt the phenomenon of moving away as possible in protection, so a confrontation distance of 30 meters was adopted in this study.
2- The building is safe under the influence of lateral loads, where the permissible displacement < maximum displacement.



3- As for the overturning moments, the manually calculated torque is less than the torque obtained from the program.



4- The shape of the final deformations in the building is as follows.



The research reached a number of recommendations which are summarized in:

- A potential fire inside the building may increase the damage, so the building must be designed to resist fire.
- Fortified structures must be flexible enough to absorb the forces of explosion without collapsing.
- The interior design and the external architectural appearance greatly affect the explosion resistance.

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- The height and specifications of the building are among the parameters that affect the explosion resistance, as the lower the height of the building the higher.
- Designing explosion-proof buildings is relatively expensive, because due to the limited budgets of many building projects, the additional cost of buildings that provide explosion-proofing may seem prohibitive. However, the average cost of explosion-proof design in a new structure is much less than the cost of repair or the restoration of the normal structure according to similar standards.
- The layout of the building, safety distances and architectural aspects must be taken into account.

CONCLUSIONS

1- Designing buildings to withstand blast loads is a very complex procedure that has been investigated for many years and requires further research.
2- Techniques for designing explosion-proof buildings controverts with the aesthetics and budget constraints of building.
3- Blasts usually lose their energy as they move away from their source, so where possible the most cost-effective approach to maintaining building integrity is to increase the standoff distance; keeping the bombs away from the building. Careful site planning can help in this matter, and in a non-architectural aspect that helps improve safety; Increasing the number and quality of security personnel.

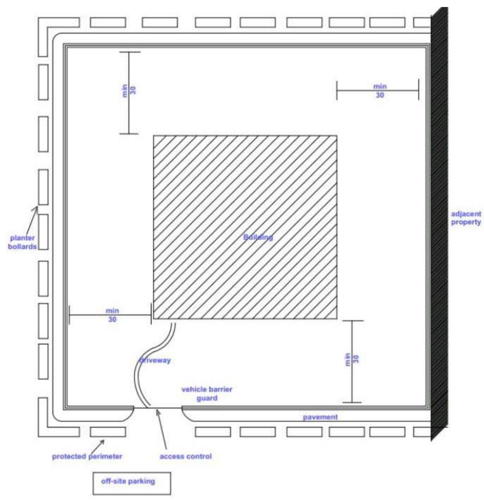

Figure (6)

Layout of the bomb protection site

4- Buildings resist explosions better by increasing mass; Where the explosion energy is absorbed more easily by the massive structures, this makes reinforced concrete the main material suitable for the design of buildings that are resistant to explosions.
5- Flying shards of glass are one of the main causes of injury after the explosion so it is recommended to cover the windows with no more than 15% of the wall area between the supporting columns.
6- The doors must be arranged in an eccentric way in the corridors to prevent the entry of explosion pressure into the interior parts of the building.
7- the structural form of a feature that significantly affects the explosion loads on the building; Therefore, complex shapes are not encouraged because they cause reflections of the blast wave.
8- One of the cause that led to the lack of sufficient studies on this subject is the lack of architectural and construction maps for most of the buildings that have been directly and indirectly targeted.

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