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ANALYSIS OF DAMAGED R.C STRUCTURES DUE TO EXPLOSIVES AND EVALUATION USING MODELING AND COMPUTER SIMULATION

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Summery. Engineering structures generally subjected to set of factors affecting these structures during utilizing period, which consumes structural member resistance by influencing construction materials and structural systems.

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Effects in structures appears in the form of cracking and deflections in members, which differ in patterns and dimensions, and vary from tiny cracking to considerable deformations and sometimes structural failure.

Engineers worked during the last few years on rehabilitation of structures and analyzing defects that appear due to normal effects (execution problems, age, soil problems, et…), besides defects due to accidental hazards. However, Since September 11th 2001 a new trend in structural science appeared, which is restoration and rehabilitation of structures that are damaged by accidental hazards (Explosions).

Shells and explosions have huge destructive effects on structures and buildings, when a building is damaged by an explosion there are few basic concepts must be considered in order to start work, such as exploring the building and investigating the problems by analyzing effects in the location.

In Syria, many cities were severely damaged by the war, which led to lots of destruction in structures both completely demolished and partially damaged.

This research represents the basic methods and concepts in structures evaluation, and investigating damages that happened due to accidental hazards (Explosives). Also analyzing reinforced concrete structures behavior due to direct and indirect effect of explosions, besides using computer modeling software to analyze behaviors in order to provide the most suitable procedures of rehabilitation.

1- Explosive load sources:

1-1- Introduction:

Explosive loads sources are usually categorized into two basic types, Traditional explosions and Nuclear explosions, table /1/ represents sources of each type: [1]

1-2- Explosion Destructive Effects:

In order to understand deferent structures response due to explosions loading we must know basic destructive effects of an explosion: Explosives have four main effects fig. 1: [3]

1-2-1 Shock wave.

Major compression in the air particles affecting objects in the form of shock wave with considerable amount of energy followed by loosening in the close circle to the explosion location, causing objects and persons to be thrown in the air, besides possible cracking in structural and non-structural members of buildings.

Generally, Shock wave considered to be the most important effect in an explosion. These effects varies according to explosion location for the building and earth surface. Fig. 1, 2, 3, 4.

1-2-2 High Temperature.

Explosions release in the close circle high energy in the form of flame with very high temperature, which could be sudden and concentrated but sometimes could release long term fires in buildings affecting construction materials properties. Fig. 1.

1-2-3 Fragments.

Fragments are considered to be serious danger on lives and structures resulting from the explosion in the form of random shells that might impact with structural members causing heavy or partially damage in addition to destroying non-structural materials.

1-2-4 Sound Wave.

Sound wave is the last and less effect resulting from an explosion which considered neglected comparing to the previous.

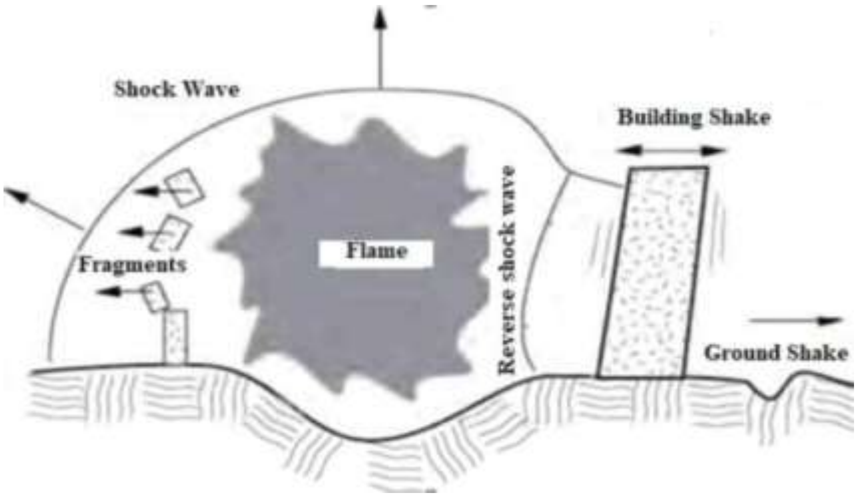

Fig. 1. Explosion main effects

Fig. 2. Shells and missiles possibilities on buildings

2- Prediction of Blast Pressure and Explosive Loads: [2, 3]

2-1- Impulse pressure diagram:

Shock wave resulting from explosion and striking the building in the form of pulse with two phases (positive and negative). Fig. 3.

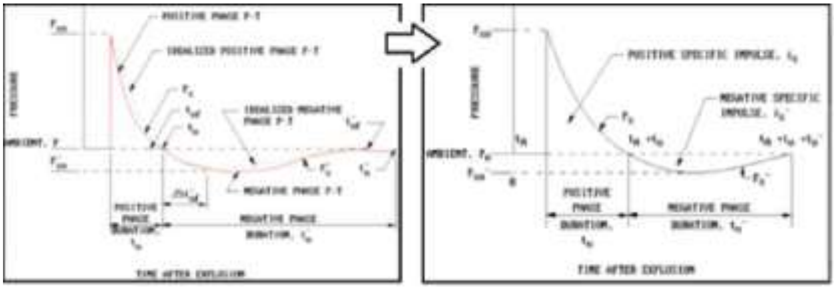

Fig. 3. Ideal pressure-time & Free field pressure-time variation.

Blast wave parameters for conventional high explosive materials have been the focus of a number of studies during the 1950's and 1960's. Estimations of peak overpressure due to spherical blast based on scaled distance Z = R/W1/3 were introduced by Brode (1955).

Newmark and Hansen (1961) introduced a relationship to calculate the maximum blast overpressure, Pso, in bars, for a high explosive charge detonates at the ground surface.

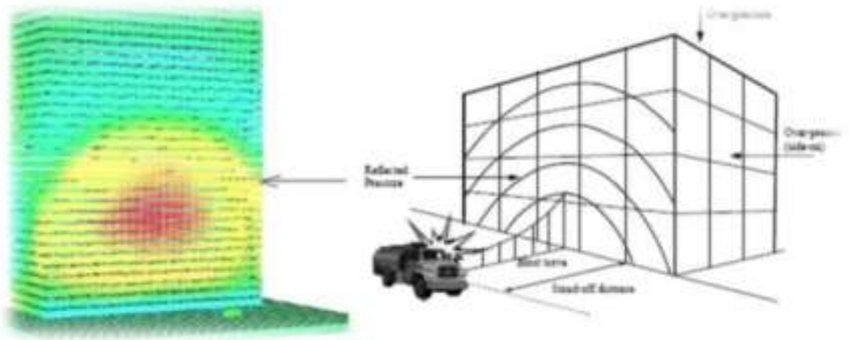

Fig. 4. Blast Loading on Buildings

2-3- Explosive Pressure Loading on structures:

Compression load of an explosion could be evaluated using modern technologies in simulation and computer modeling. That we can create computer model for structural members as per reality taking into consideration the deformations in the structure after an explosion, by applying deformations and comparing resulting displacements in computer model with reality we can predict loads that caused these deformations.

Using this approach, we can predict initial stresses in members under blast loading.

3- Structural Members Response due to Explosion Pressure: [6]

Structural members have deferent responses due to explosion loading, and these responses varies according to few factors:

Structural system of building and members measurements.

Construction materials used.

Distance between explosion location and building.

Explosion source and type of explosion.

Detonation general location.

Structural response in buildings have many patterns according to explosion loading and detonation source:

3-1- Elastic deformation:

Instant deformation in structural member (slab, beam, column, shear wall), usually this displacement takes horizontal direction and in some cases could be vertical, considering that the members deform during the positive phase of shock wave then returns back to its basic situation, and in many cases the member cracks but still in service without any loss in cross section fig. 05.

Fig. 5. Elastic deformation in simply supported beam due to blast loading

Elastic deformation in structures subjected to blast loading happens due to following reasons:

1. Uniformed construction materials with high quality that provide sufficient density for the patch and cross sections.

2. Using steel reinforcement meshes in small diameters and adjusted uniformed spacing between bars, providing good interaction between concrete and steel to resist pressure loading. Fig /07/

3. Long distance between detonation location and subjected member, that the member is still in service because it's still able to resist accidental pressure.

3-2- Cracking and loss in cross section:

As a result of mid-strength shock wave or when the structural member is tough enough so that does not collapse under missile strike but losses part of the cross section while stays in service but in critical condition (safety factor = 1). In this case the member will not be able to hold any additional load.

Fig. 6. regular steel reinforcement meshes in column after blast

When the building is subjected to direct strong impact, some of structural members parts form fragments in addition to blast fragments. This case causes serious damage for other structural members in the building and lives.

Fragmenting fin structural members due to blasts has two basic reasons:

1. Non-uniformed cross section, lack of cement mortar in concrete mix.

2. Direct strike or impact by missile or fragment from other.

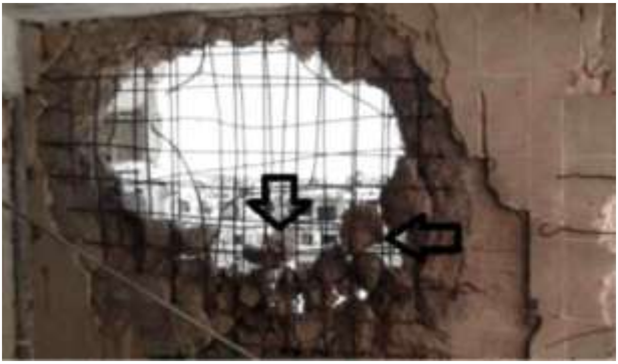

Fig. 7. Fragments in structural members

3-4- Partial or overall collapse:

Partial or total collapse of building subjected to blast loading takes place when the building is located in a very strong shock wave circle or when a very destructive missile strikes the building causing several structural members to be out of service leading the structural system to failure.

Fig. 8. Partial & total collapse of building