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Investigation of the effect of surface explosion on the concrete walls of the war shelter reinforced with GFRP sheets

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ABSTRACT: The importance of developing passive defense systems requires the study and analysis of structures in this area due to surface explosions. Due to the localization of the explosion phenomenon and the effects and environmental characteristics and existing obstacles, this phenomenon has special complexities. In this research, using the finite element method and with LS-Dyna, the nonlinear behavior of the walls of concrete structures reinforced with GFRP in a war shelter against The charge due to the impact of the surface blast wave is simulated and investigated in a more precise three-dimensional space. In this study, the explosive load, abutment conditions, wall dimensions, fiber material, and characteristics of the materials used are considered the same, and the effect of different reinforcement modes with GFRP sheet and their thickness in these modes is investigated. First, the stress distribution in the walls of the reference concrete structure was calculated and the critical areas of the structure were identified. Then, the response of the walls of the reinforcement structure in the critical area with different thicknesses is compared with each other and with the reference structure and the effect of using this reinforcement method for the walls of the structure against surface explosion loading is determined. Finally, the amount of displacement and stress distribution for different geometric locations of GFRP sheets is calculated and due to the extraction of the optimal state of reinforcement against full coverage of the walls of the structure, the use of this method in this method is considered appropriate.

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1- Introduction

Carrying out a safe and optimal design that provides maximum efficiency with minimum cost requires accurate knowledge of the effects of explosion and impact on the structure as well as the behavior of the structure against the effects. Of course, it will not be possible to obtain such information except by doing a simulation close to real conditions. The main goal in impact and explosion engineering is to accurately understand the explosion phenomenon, the behavior of different waves caused by the explosion, the interaction of the structure with impact waves, the way projectiles move and function, how energy is consumed during impact, and briefly all cases and issues related to explosion and impact. is. Due to the existence of many complexities, performing the desired analysis in the field of impact and explosion engineering requires the use of software with special capabilities and capabilities. One of these powerful hydrocodes in the field of explosion is LS-DYNA software, which has very high capabilities in solving nonlinear dynamic problems. [1]

2- Methodology.

2- 1- Definition of explosion

Many methods have been proposed to calculate the load caused by the explosion, in fact, all the quantities related to the explosion are dependent on two independent quantities, the amount of energy released during the explosion and the distance between the center of the explosion and the place of the impact of the blast wave. The destructive power of a bomb is also calculated by these two very important quantities. The interaction of two quantities, the weight of explosives (W), which is equivalent to the weight of TNT, and the distance of the effect of explosives (R) is called the scaled distance (Z) and is expressed as follows [2].

$$z = \frac{R}{w^{1/3}} \tag{1}$$

In the above relationship, R is used in meters and W is used in kilograms. The effective variables in the explosion phenomenon as well as the appropriate relationships to estimate the pressure caused by the explosion have been the goal of many scientific researches in the 1950s and 1960s.

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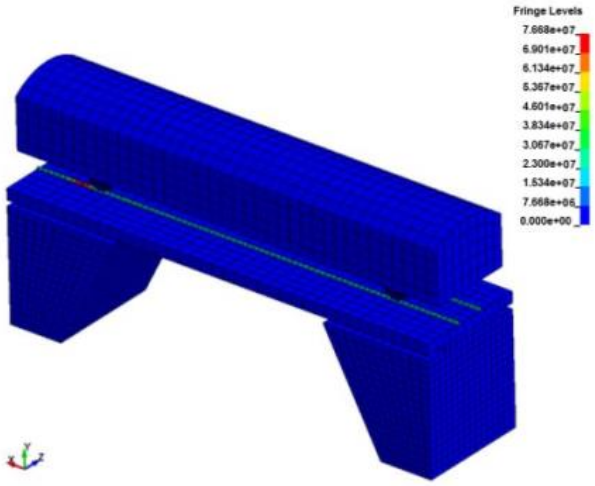

Fig. 1. Stress distribution countour on the modeled rail

For the first time, the maximum explosion pressure (PSO) using the scaled distance, Z, was expressed by Borde in the question of 1955 in the form of relations (1) and (2) [3]

$$P_{so} = \frac{97.5}{z} + \frac{145.5}{z^2} + \frac{585}{z^3} - 1.9 \quad KP \quad (10Kpa \prec P_{so} \prec 1000Kpa) \tag{2}$$

$$P_{so} = \frac{670}{z^3} + 100 \quad KP \quad (P_{so} \succ 1000Kpa) \tag{3}$$

Also, the newer relationship provided by Yazifared and Maheri is as follows [4].

$$Log_{10}(\frac{t_d}{W^{1/3}}) \approx 0.28 + 0.3Log_{10}(\frac{R}{W^{1/3}}) \quad (Z \geq 1/0) \tag{4}$$

$$Log_{10}(\frac{t_d}{W^{1/3}}) \approx 0.28 + 2.5Log_{10}(\frac{R}{W^{1/3}}) \quad (Z \leq 1/0) \tag{5}$$

2- 2- Modeling and verification of analyses

In order to ensure the accuracy of the modeling and analyzes and due to the lack of facilities for conducting explosion tests and measuring the stresses applied by the explosion on the structure, from the results of the article simulating the effect of the explosion on the performance of rails and bridges, which is based on the Lagrangian method for extracting the stress distribution on The steel rails of a bridge, which are special for the passage of wagons, have been used. In the mentioned research, the modeling of the problem was done in ANSA software, the simulation was done and the results were extracted in LS_DYNA software [5]. According to the stress distribution extracted for the modeled state of the problem analyzed in the article, which is shown for the rails. The stress contour in the rails of the cited article shows a maximum stress of 25 MPa, which is equal to 27.5 MPa (average stress from 23 MPa to 30 MPa) in the stress contour of a similar state modeled according to Figure (1), which is correct according to the simulation conditions. And it is reliable.

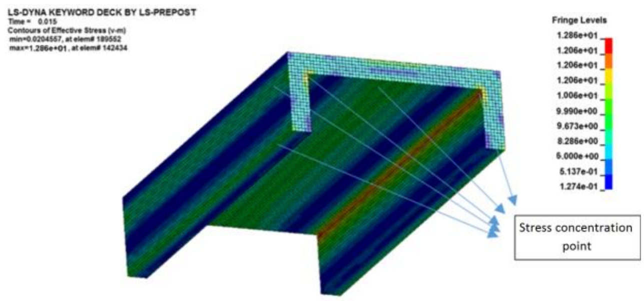

Fig. 2. Stress contour in the reference structure

As shown in the stress contour of the reference structure in Figure (8), the stress has increased in several areas of the structure due to stress concentration. Among these areas in the lower corners which are located on the outer side of the target structure, the stress concentration is caused by assuming the side walls are in contact with the surrounding soil and is not part of our goal to strengthen the structure. But there are three areas of the target structure that must be strengthened. These areas are: from the upper corners inside the structure and the middle of the roof of the structure, the maximum stress in these critical areas is approximately equal to 11 Mpa, which is also displayed in the stress contour.

To extract the stress contour, the structure is modeled in three dimensions and with the specifications of the mentioned elements in five different thicknesses, and after applying the explosive loading, the results obtained are both in the mentioned table and in the form of a textual explanation in the continuation of the review, as well as the graph of the analysis results. It is also extracted according to figure (3).

3- Conclusion

From investigating the behavior of reinforced concrete walls of tunnel shelter with GFRP sheets against surface explosion by finite element software LS-DYNA, the following results can be expressed.

- Reinforcement using different thicknesses of GFRP sheets has a significant effect on the performance of the structure against the explosive load, and the optimal thickness mode (thickness of 9 mm) reduces the maximum stress of the structure up to 2 times.

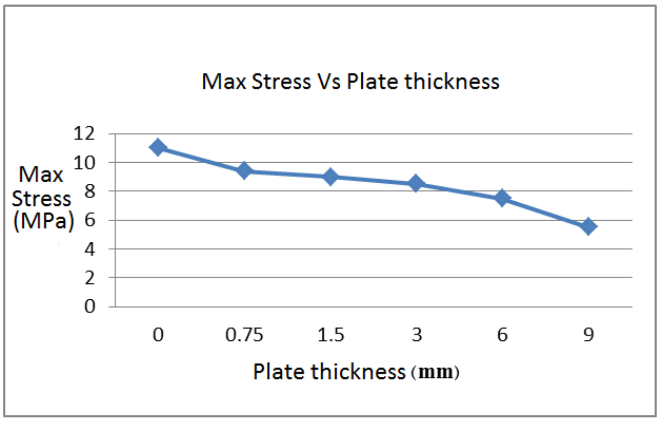

Fig. 3. Comparison of the maximum stresses created in the reinforced structure with different sheet thicknesses

- The use of different states of geometric placement of strips in front of the full wall covering is effective on the performance of the structure against the blast load and reduces the maximum displacement and the maximum stress created in the structure by nearly 2 times.

- The results of the analysis show that only the strip covering of the structure in the geometric placement of the first state with a thickness of 3 mm is better than the complete covering of the walls of the structure, which is also due to the release of strain energy.

- The results of the present study indicate that increasing the thickness of the sheet will have a direct effect on reducing the maximum stress created in the structure.

- In the present study, two thickness parameters and different geometric placements were discussed, among which 9 mm thickness and strip geometric placement along the length of the shelter (geometric placement of the first mode) result in the best conditions for strengthening the structure.

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