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Research Article

The Effect of Amount of Explosive Material on the Destruction Rate of Adobe Dome Buildings - Case Study Imam Reza Shrine

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ABSTRACT

Increaseing terrorist attacks around the world and the possibility of bombing near the buildings and old-religious sites are serious. The sanctuary of Imam Reza's shrine is important for many aspects. Apart from the historical origin of the building, which is a common factor between historical structures, its religious values and its continuous use make it more distinct from other historical buildings. In this article, The Effect of amount of explosive material on the destruction rate of adobe dome buildings - case study Imam Reza Shrine is paid. It was found that if 10 kg of TNT were exploded in the middle of the dome and on the ground, there would be no serious damage to the dome, and the tension strength would be less than the material strength, but if it was around 20 kg, it would destroy the wall and thus the dome. The explosion simulation with the Autodyn and shrine dome was done with Abaqus.

Keywords: Explosive Material; Adobe; Dome bulidings; Abaqus; Autodyn.

1. INTRODUCTION

The first Identifying the risk of potential injuries plays an important role in preparing for exposure and counteracting the negative effects of terrorist attacks on urban areas. If the recognition of the dimensions of these risks to urban areas and the possible damage properly has considered. It is possible to broadly define and develop the level and type of coping with these injuries to the scale of one-to-one buildings [1]. Purpose of the pathology is identification of facilities and solutions for the protection of buildings against terrorist attacks and effects of the explosion. Due to the fact that the resistance of a building against the explosion wave depends on the shape and form of the building Roof, number of valves and openings, power and the material used in the building. As a result, studying and evaluating the shape and form of building roofs against the consequences of the explosion is important. Given that more terrorist attacks are blasting on the ground, more explosions affect the roofs of low-altitude buildings than high-rise buildings because of the explosion waves do not reach the roof in high-rise buildings and absorb the periphery of the building. Due to the variety of shapes used in the roofs of buildings that designers use in their designs. This defect is felt to be more stable and resilient against the effects of explosions in countering terrorist attacks. Choosing the shape and form of the roof of the building on the plan and the height can have a great effect on improving the behavior of the structure in the explosion and reduce the damage [2].

One of the researchers who have done a lot of research on explosions is Luchiniuni, whose articles refer to the behavior of concrete slabs impacted by explosive charges. In this paper, he initially tested the concrete slab under the blast, and then compared the results with modeling the problem by using AUTODYN and ABAQUS software, thereby proving the accuracy of their modeling. Then, it attempts to provide a relationship between the diameter of the cavity due to the explosion and the weight and location of the explosion. Finally, a comparison is made between the models and the software used, and in each case it describes the weaknesses and strengths of the software [3]. In 2010, Gigen and Togeh conducted research on the geometry of the building as well as the impact of the perimeter of the building on preventing the arrival of explosive waves into the building, and concluded that in geometric shapes, the maximum and maximum shaking pressures were substantially distant from the site of the explosion And the angles of explosive shock and resistance to flow and waveforms. The shape of the elements of a structure or a structure can definitely reduce the explosive loads [4]. Other investigations can be made by M. Barakat and J. G. Hetherington. They have explored the effects of explosions on various forms of building, such as cubic, cylindrical, semicircular and prismatic forms, and concluded that in addition to building components, architectural forms can also have a significant impact on reducing the impact of explosions on buildings [5]. Mojtahed Poor's research from the University of the Persian Gulf could also be investigated. He has investigated the effects of structural form on the distribution of stress caused by explosive loading, which has more than a structural aspect to the subject, in part; it has affected the existence of hardening in the structure [6].

A structural structure is a type of structure used in the construction of independent units in a layer and used in the layers of mortar. Commonly used in the construction of structures or walls is materials such as brick, stone, marble, marble, travertine, limestone, cement block, glass block, plaster, cement and tile. Due to the great oldness of the mosque and especially the shrine of Razavi, the materials of these places are usually of traditional materials and, given the climate of Iran, these buildings are masonry buildings [7].

The sanctuary of Imam Reza's shrine is important for many aspects. Apart from the historical origin of the building, which is a common factor between historical structures, its religious values and its continuous use make it more distinct from other historical buildings. In this article, The Effect of explosion distance on the destruction rate of adobe dome buildings - case study Imam Reza Shrine is paid. The explosion simulation with the Autodyn software and simulation of the shrine dome was done with Abaqus software.

2. Determine the force of the explosion

The explosion is associated with a sudden increase in volume and sudden release of energy, which is usually accompanied by an increase in temperature and release of gas.

Two standard methods have been mentioned in the references for the estimation of the explosion force. In this paper, introducing these two methods, the results are presented.

3.1. Determine the explosive force by analytical method

In this method, explosive equations can be used to calculate the impact of explosions at different distances. The relationship provided for this is as follows

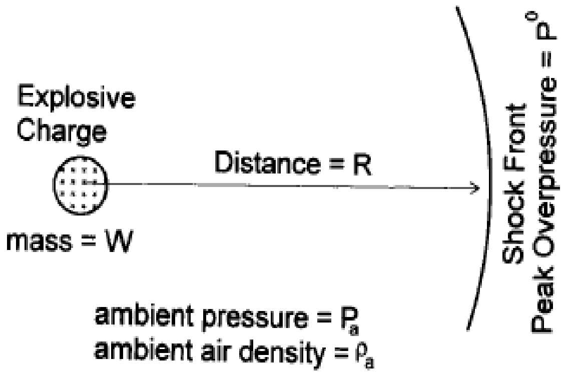


Fig.1. - Parameters effective in analyzing the explosive force

$$\left(\frac{p^0}{p_a}\right) = f\left[\frac{R}{\left(\frac{wT_a}{p_c}\right)^{\frac{1}{3}}}\right] \qquad 1$$

In the above case, p_a is the ambient pressure, p^0 is the explosion pressure, R is the distance from the explosion, W is the amount of explosive and T_a is the ambient temperature [8].

Using this method for 10 kg of TNT, the pressure at the explosion site (0.1mm from the explosion center) is 78Kbar, that is, 78000 times than the ambient pressure (about 7800MPa).

3.2. Determine the explosion force using the Autodyn software

The exact simulation of the explosion process depends on three issues: the choice of a suitable numerical method, the selection of the appropriate material model, and the availability of material coefficients with high precision of the explosive substance. In general, there are 3 numerical methods for analyzing the explosion process: Eulerian, Lagrangian and SPH. In Euler's analysis, meshing during static deformation remains constant, and this technique, which is time consuming, is usually used to calculate fluid flow.TheLagrangian analysis, in which the mesh with the material deforms, has the advantage that the rate of analysis is higher and the contact surfaces of the various materials together in it are properly defined. Using this method to model the explosion process requires the definition of an appropriate erosion algorithm. This algorithm works on the basis that the Lagrange region that reaches a certain degree of strain (usually 150%) is eliminated. The value of this strain is defined by the user. Although this method is a suitable tool for modeling the explosion process, it should be noted that this technique does not have the ability to accurately simulate the real physics of the problem. SPH is a relatively new method for the dynamic analysis of continuous materials, which is in fact a special technique of the Lagrangian method, and is capable of analyzing the exact and exact levels of the collision of different materials, and is flexible in applying various material models. Also, due to the fact that this method is non-mesh, the problems associated with the deformation of elements exposed to extreme deformations in the ordinary Lagrangian method are not available in the SPH method, and it is not necessary to define the erosion algorithm. In general, this method has the power to model the process of exploding and submerging materials that is closer to the real physics of the problem [9]. In order to obtain accurate results, it is necessary to use a fixed size particle to model the SPH.In this paper, AUTODYN software and SPH method have been used.

Using the AUTODYN software, a 10kg TNT bomb is modeled on the surface of the ground. Figure 2 illustrates schematically the modeling explosion.

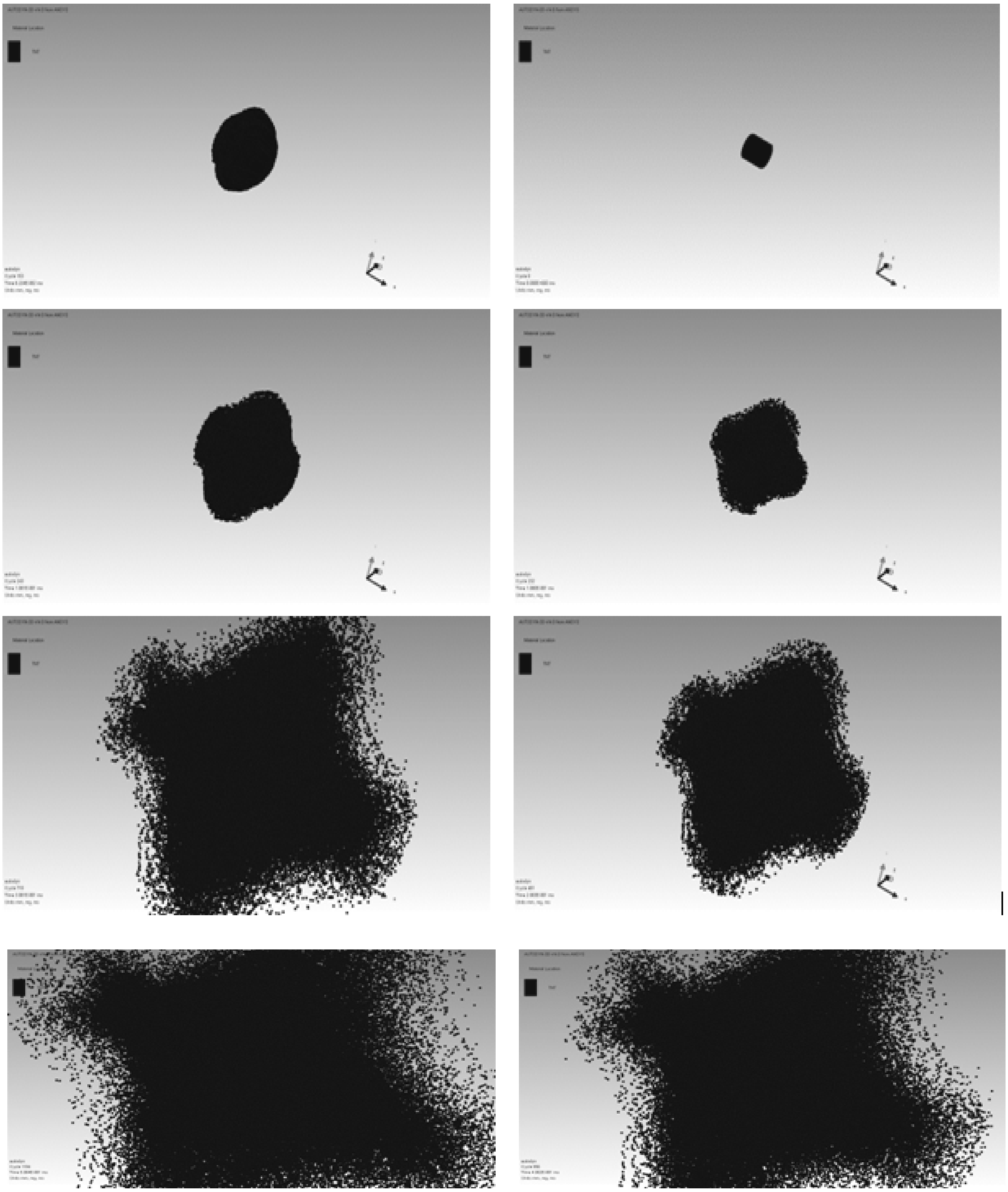


Fig.2. - The simulated explosion display in the AUTODYN software

In order to accurately examine the modeling results, in Fig. 3, the pressure diagram is shown on a point attached to the explosive at the time of the explosion. It is found that the maximum pressure is about 8000MPa, which comes to a level within a fraction of a second (about 0.01 milliseconds). In fact, an explosion wave is created, which moves the wave quickly and exerts pressure on its surface.

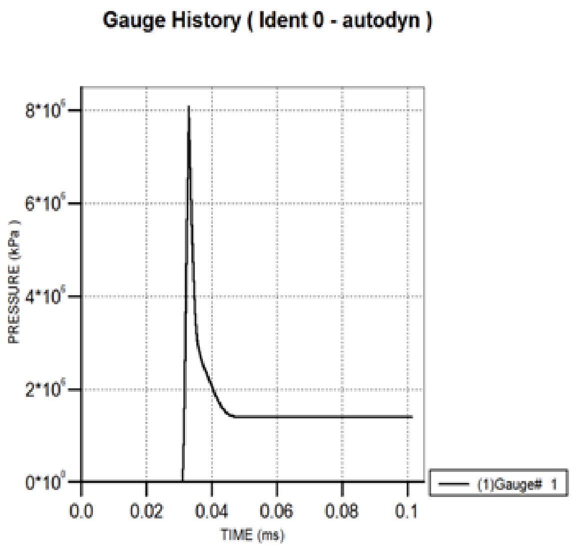


Fig.3. The pressure diagram applied to a point adhering to the explosive at the time of the explosion

As seen in the analytical relationship, the explosion wave is reduced by increasing the radius. This decrease in the power of the explosion wave is directly related to the cubic radius.

3. Modeling the shrine dome

The roof of the shrine is in the dome section of the two skeletons. The dome has two covers: the first covering, the roof visible from below (inside the shrine), and the second coat is placed over the first coat and is covered with golden bricks and exposed to the public. Dimensions of the dome are as Table 1

Table 1. Dimensions of the dome

The height from the shrine floor to the bottom of the roof	18.8 m
The height from the shrine floor to the end of the gold dome	31.20 m
Round dome from outside surface	42.1 m
The height from the first gilding to the tallest dome	16.40 m

Fig.4. Shaped view of the shrine dome

For the modeling of bricks and mortars in Abaqus, two methods of micro-modeling and macro-modeling are used that are modeled on the first of each bricks and a large number of assembled elements are used for the modeling of the brickwork, but in the latter of The separation of bricks and mortars is neglected and a general element with average properties of brick and mortar properties is used. In the case study of the dome of the shrine, a moderate perspective was used to reduce the time spent on the micro analysis due to the large size of the dome, and in the parts of the dome requiring injection of expanding materials, use this view and seam Mortars are modeled.

4.1. Determine the properties of materials used in the holy shrine

In order to obtain the physical properties of the materials used 5 samples of 20 x 5 x 20 cm, with a 20 mm thick mortar layer forming a piece of building materials and the necessary tests are carried out and obtained specifications of the materials according to the table 2 which was used in software assumptions. It should also be noted that the Poisson coefficient used in this study, using previous studies by Dora silveire&Humbertovarum&Anibal costa, has been about the effect of test processes on determining the mechanical properties of adobe bricks. Mechanical tests shown in Fig 5.

Fig.5. Tests on samples

Table.2. Physical Properties of Materials

Dilation Angle	Flow Stress Ratio (K)	Angle of Friction (β)	Compression Strength fc	Tension Strength ft	Poisson Ratio v	Young Module E	Density ρ
20	0.8	46	3.5 Mpa	0.38 Mpa	0.15	1900 Mpa	1800 kg/m^3

Drucker-Pruger model was used to model clay in software [10]. For modeling, the shell element has been used.Given that the force is explosive, and this time is dependent on time, it should use dynamic loading, which is defined in the step module. The Dynamic Explicit module is used and the duration of the solution is considered in accordance with the explosion charge.

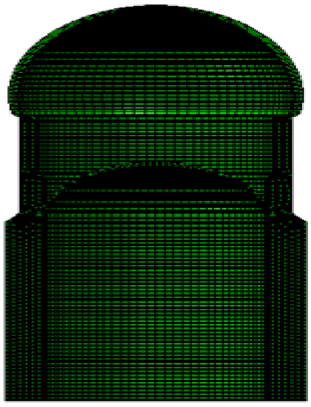
4.2. Apply boundary conditions and loading

Since the surrounding walls are very thick and fixed to the ground, in the simulation, the bottom of the wall is fixed and there is no degree of freedom.

4.3. Mesh study

Linear quadrilateral elements of type CAX4Rl have been used to mesh. After meshing, the sensitivity analysis of the model should be done relative to the dimensions and number of computational cells. In this project, this is done by modeling a sample problem with different densities of computational cells and comparing the results with each other. The number of elements used is 414,351, which, given the huge volume of the structure, has a lot of time to solve. Each run lasted about 3 days. Figure 6 is showing elements.

Fig.6. Meshed Model



5. Analytical results

5.1. 10kg TNT

In this assumption, the explosion occurs on the ground and in the center of the dome, so the distance between the walls of the explosion center is about 6 meters and the ceiling is about 18 meters. To assume an increase in safety factor, the minimum distance is assumed to be considered. (6 meters). The Von Misesstress affects the dome as shown in Figure 7

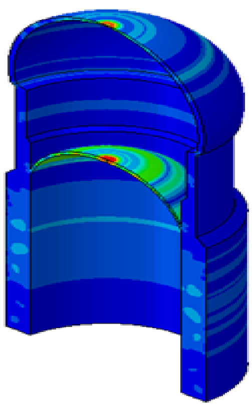


Fig.7. Von mises stress on dome

As it is known, stress on the shell is more than the rest. This amount of stress is due to the accumulation of stress in those points.

The maximum stress level at the top of the load carrier is about 2.3 bars or 0.23 Mpa

It is known that the amount of stress caused by the tensile strength and the compressive strength of the materials is lower and therefore, in this case, the structure of the dome cannot be deformed.

The Von-Mises stress diagram enters the tip of the barber dome as shown in Fig. 8. As it is known, the maximum stress value is about 0.2 MPa, which is lower than the tensile strength of materials.

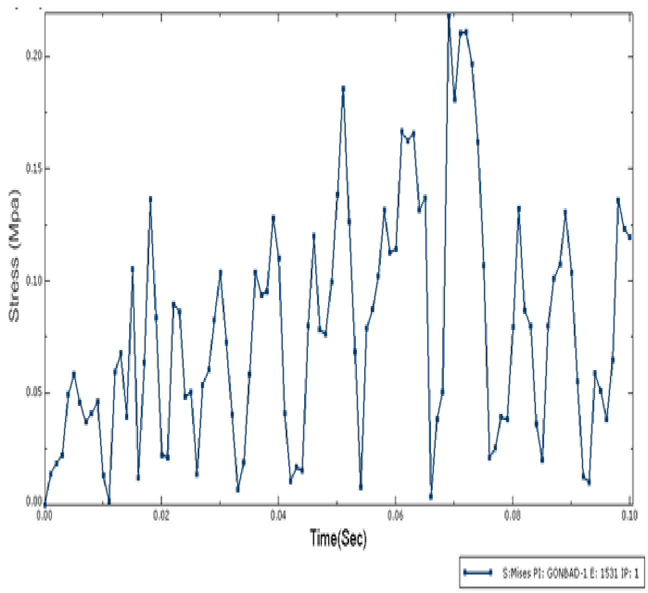


Fig.8. The Von-Mises stress diagram on dome

5.2. 20 Kg TNT

In this case, the explosion is supposed to occur on the ground and next to the walls of the dome, so the distance between the walls of the explosion center is about 10 cm and the ceiling is about 18 m.

Using the relations, the value of z = 0.0055 for a radius of 10 cm from the 20 Kg TNT explosion creates a compression equivalent to 500 bars in 0.02 milliseconds. This explosion blast creates stress as shown in Fig 9

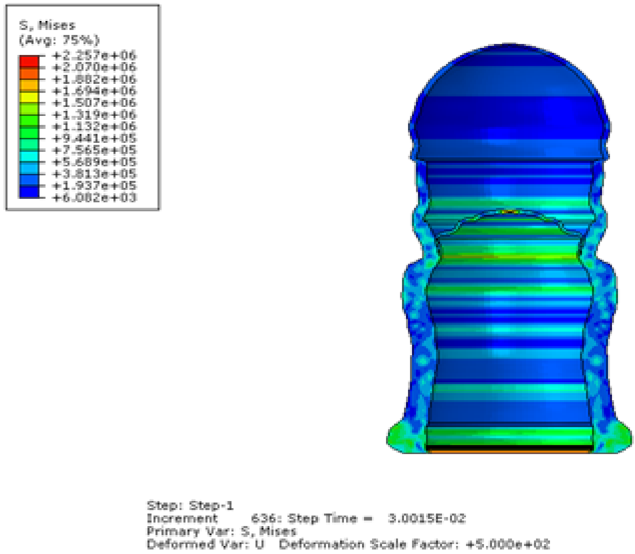


Fig.9. Damage of the load carrier in 0.03 seconds after the explosion began

6. CONCLUSION

By performing tests, the mechanical and physical properties of the materials used in the dome structure were determined. Finally, by determining the properties of the materials and also the model of the dome and with the help of pressure-time graphs, the time of the explosion was obtained; the strength of the dome structure against the explosion wave was obtained. So if 10 kilograms explode in the middle of the dome and on the ground, there is no serious damage to the dome, and the tension is less than the material's strength, but if it is 20 kg, it will destroy the wall and thus the dome.

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