Numerical investigation of bio-inspired barrier walls subjected to explosive waves

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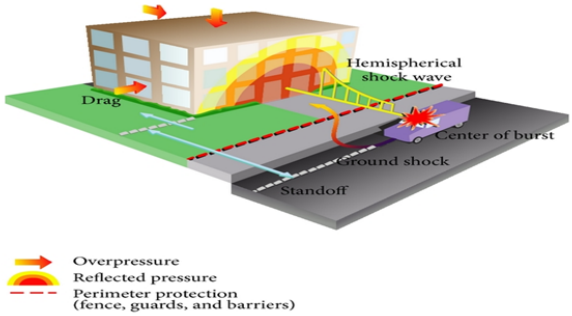
Abstract–Nowadays, the development of technology is increasing hence the probability of accidental explosions such as incident blasts, mine explosions, and terrorist attacks has increased; protecting important structures against explosive impacts has become a great concern. Hence, the current research is aimed to design a New Structural Concrete Barrier Wall Under the Effect of Different Impact Loads Using Biomimicry Technique compared to traditional barrier wall. The results showed that the new designed configuration gave a lot better performance than the flat traditional configuration in the blast loading resistance. Also, it is concluded that using the bio-mimic concept has a notable effect on reducing blast pressure. The results showed that changing the shape of a wall barrier from flat to doubled curved and cones on flat wall has a better performance in mitigating the effect of blast waves with ratio up to 26% in comparison with the traditional flat barrier wall.

I. Introduction (Heading 1)

The earthquake, wind, rain, and snow loads are essentially taken into account by the majority of design rules. In engineering, blast loads occupy a separate position from normal loads. The design of blast and the reaction of structures to blast loads are very different from other well-known loads; even the principles of blast and seismic design depend on dynamic behavior and energy dissipation methodologies. Blast loads, in contrast to seismic and wind stresses, have a brief period, often measured in milliseconds (MS). As terrorist assaults on military facilities have increased, blast design has remained popular as new design codes have been created. To withstand gas explosions in large, enclosed spaces, residential buildings have begun to integrate blast design from military structures. Hence, the first blast design



Destroyed reinforced concrete building by blast load and pressure scenarios on building

Hence, to examine the impact of blast loads with corrosion, multiple blast load scenarios for reinforced concrete buildings with and without corrosion were carried out in this work. Under the influence of blast loads, reinforced concrete structure performance levels were attained. Simulated blast wave impacts on the surface of the structural members.

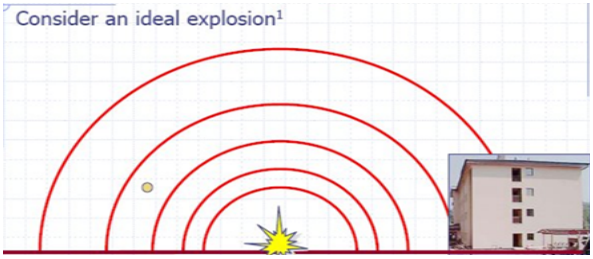
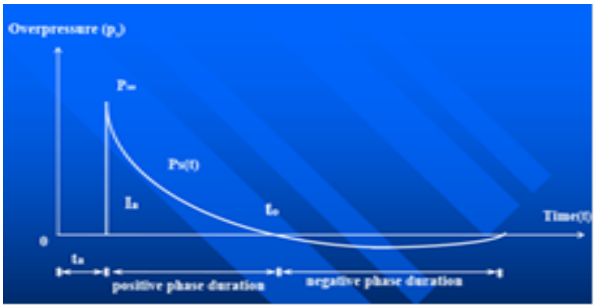


Fig. 1 a) Ideal free field blast wave profile[8]



b) The effect of blast waves on barrier wall

FIG.2 LOTUS TEMPLE IN NEW DELHI

What is meant by Biomimicry?

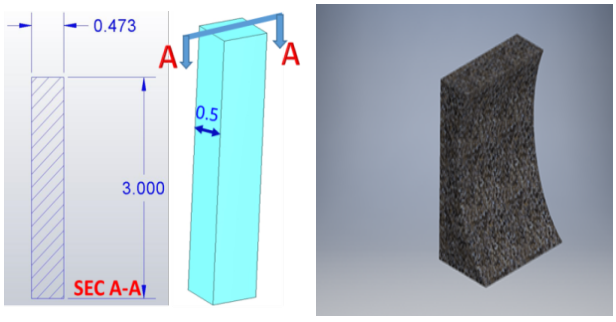
Trying to imitate the nature by getting architecture ideas from it.

BIOMIMICRY CONCEPT

VISUAL INSPIRATION IS A FAIRLY COMMON AND WELL-KNOWN TECHNIQUE. IN THIS INSTANCE, ENGINEERING SYSTEMS WITH SIMILAR APPEARANCES ARE MADE USING IMAGES OF DIVERSE LIVING SPECIES OR THEIR SYSTEMS. PARTICULARLY IN ARCHITECTURAL DESIGN FROM THE AESTHETIC POINTS OF ARCHITECTURE, VISUAL INSPIRATION CAN YIELD USEFUL RESULTS.

II. NUMERICAL SIMULATIONS:

Numerical modeling is very important for studying the effect of blast and explosive effects on various structures as carrying out experimental tests is very expensive and takes a lot of testing equipment and instructions during testing. In AUTODYN-3D the fundamental equations together with the boundary and initial conditions are solved using FE modeling.



How to reduce the effect of blast wave

To decrease the losses of life and building resources, protecting structures against blast load is explored extensively with numerous strategies or procedures. One of these ways is using varying sizes and shapes of Barriers to diffract the blast wave, leaving behind it a complicated flow field that varies the load applied on the target.

Barrier Walls

The barrier wall's ability to sustain the pressure wave's impact on the area behind the barrier was experimentally investigated in this study using a scaling method. In this investigation, 10 k g of hemisphericalshaped.
TNT explosive charges were placed on a barrier wall to test tw o parameters: standoff distance and barrier height. The properties of the used materials are shown in table 1:

Table (1) properties of used materials

Material	Equation of state	Strength model	Reference density
Concrete	P-alpha	RHT	2.75
Comp. B	JWL	-----	1.71
Air	Ideal gas	----	1.225*10-3

During numerical simulation, the remap technique was employed (Dynamics 2005). First, a 2D domain was used to calculate the explosive's initial detonation and blast wave propagation in free air. The output was then remapped into a 3D space. By using this method, the model can be improved and run faster. To allow the blast pressure to dissipate outside the air domain without reflecting and harming the concrete target, flow-out boundary conditions were applied to the air domain's exterior surfaces.

The Lagrange solver is used to describe the concrete target. The Jones-Wilkins-Lee equation of state, which simulates the pressure produced by chemical energy in an explosion, is used to model Comp B. One of the most basic types of equation of state, the ideal gas equation of state, was used to model air.

2.3 Numerical results and discussion

This part introduces and presents the results of different pressure gauges fixed in various locations on the behind and wall of concrete barrier and behind it as presented in the following figure to introduce the effect of angles of curvature and various shapes of the wall barrier.

Table 2 and Table 3 present the maximum pressure calculated for each gauge for the propsed models and Percent of reduction between Traditional wall and propsed walls. The pressure vs. time histories are calculated at each gauge to analyze the peak pressure at the designed models. Moreover, the response of the wall barrier on the pressure back of the wall is also calculated by evaluating the pressure at gauges 7,8, and 9.

Table (2) peak pressure for gauges

gauges	Traditional	DCurved
Gauge 7	143.34 psi	107 psi
Gauge 8	131.56 psi	106.76 psi
Gauge 9	127.03 psi	105.1 psi

Table (3) Percent of reduction between Traditional wall and other walls

gauges	Curved
Percent of reduction of Gauge 7	22.1%
Percent of reduction of Gauge 8	23.5 %
Percent of reduction of Gauge 9	26.345 %

It can be shown from tables 2,3 that the curved configuration reduces the peak pressure up to 26% with respect to the traditional configuration

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III. Conclusion

In this study presents the response of new geometrical configuration of concrete wall barrier subjected to explosive waves and a non-linear 3d numerical model is conducted to model the designed structure configuration. The response of changing the structural configuration of the wall barrier is examined. After comparing the proposed structural configuration in the current study, the curved configuration reduces the maximum pressure up to 26% with respect to the traditional configuration

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