# A Study on Blast Mitigation by Meandering the Possible Blast Impact

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*Abstract* - **In response of the increased terror threat in recent year, there is an increasing trend in blast mitigation at sites that are categorized by an increased likelihood of being the target of a terrorist attack. A latest data reveal that unprotected areas of mass congregation of people have become attractive to terrorist groups. Such control zones could be located within the building that has to be protected or attached to it. Elevated security needs for these areas call for a design that will consider the risk of internal explosive events. This study includes strategy for limiting the consequences of an internal blast, while guaranteeing that the produced blast wave does not propagate into vulnerable areas. The introduction of a protective wall system in the form of a meander that allows unobstructed access of the public and at the same time reduces the possible blast inflow to the building's interior. ANSYS software is used to assess the possible blast pressure and structural damage of the protective wall.**

***Keywords—Control Zones, ANSYS, Protective Wall***

## I. INTRODUCTION

Research on the use of fibers to increase the strength of both blast and impact structures has typically been limited to steel fibers and, to a lesser degree, polypropylene fibers. Carbon fibers possess many potential benefits over other fibers, including stiffness and high strength, as well as increased durability. Carbon fibers are very economical as they are readily available as a waste product from the aerospace industry.

The use of long carbon fibers within a concrete mix can be an economical option for improving blast resistance with distinct advantages over other blast-resistant materials. The long carbon fibers will also reduce secondary fragmentation by improving the spalling resistance of the concrete which is a critical property for protecting personnel and equipment during a blast and difficult to prevent with current materials. With the use of long carbon fibers, these improvements come with little to no modification of current design practices, allowing implementation to occur quickly and easily.

Two concrete models one without long carbon fibre and one with long carbon fibre incorporated is taken into account for analysis in ANSYS. Blast load at an eccentricity 0mm, 500mm, 1000mm and 1500mm is studied for both the cases. The parameters studied are directional deformation and normal stresses along the direction of application of load.

## II. MODELLING

M30 concrete wall with C - shape without steel plates is analysed in ANSYS-Autodyn to study the behaviour of concrete in such a high strain loading. The properties of concrete used are tabulated in Table 2.1

Table 1. Material Properties

| Properties | Value | Unit |
|---|---|---|
| Density | 2400 | Kg/m$^3$ |
| Young's Modulus | 30000 | MPa |
| Poisson's Ratio | 0.18 | - |

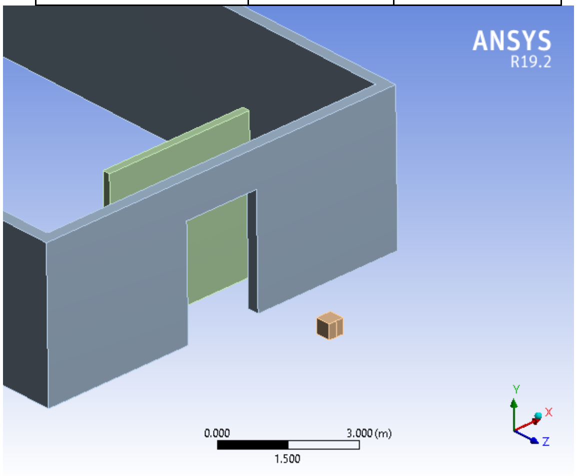


Fig. 1. Modelled Meandering Wall

The concrete wall is modelled in Explicit Dynamics module of ANSYS with the plan dimensions as 5m × 3m with thickness of 0.2m as shown in Fig. 1. The analysis is done by using a charge weight of 100 kg TNT at a height of 1m above ground surface with a stand-off distance of 3m. Concrete wall is modelled as a solid part and the end conditions are fixed. The contact regions are defined by bonded contact.

## III. NORMAL CONCRETE MODEL

The maximum positive deformation, maximum negative deformation, maximum normal stresses and maximum negative normal stresses are obtained as shown in Table 2.

Table 2. Consolidated Results

| Distance from Centre (mm) | Max. Positive Deformation (mm) | Max. Negative Deformation (mm) | Max. Positive Normal Stress (MPa) | Max. Negative Normal Stress (MPa) |
|---|---|---|---|---|
| 0 | 21.015 | -206.54 | 21.765 | -61.294 |
| 500 | 8.218 | -139.110 | 12.792 | -49.472 |
| 1000 | 15.529 | -191.600 | 50.724 | -31.171 |
| 1500 | 32.291 | -203.490 | 14.415 | -31.447 |

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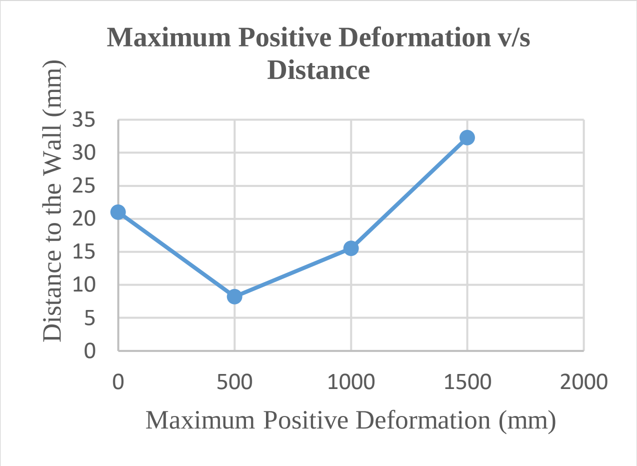


Fig. 2. A Plot showing Maximum Positive Deformation v/s Distance to the Wall

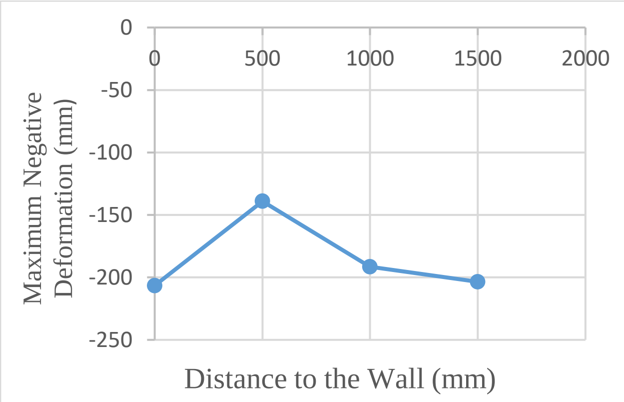


Fig. 3. A Plot showing Maximum Negative Deformation v/s Distance to the Wall

The maximum positive deformation in all cases was found to be first decreasing and then increasing. The maximum deformation was found when the detonation point was at 1500mm eccentricity from the center of the wall. The maximum negative deformation was found to be first increasing and then decreasing. The maximum negative deformation was found to be 206.54mm.

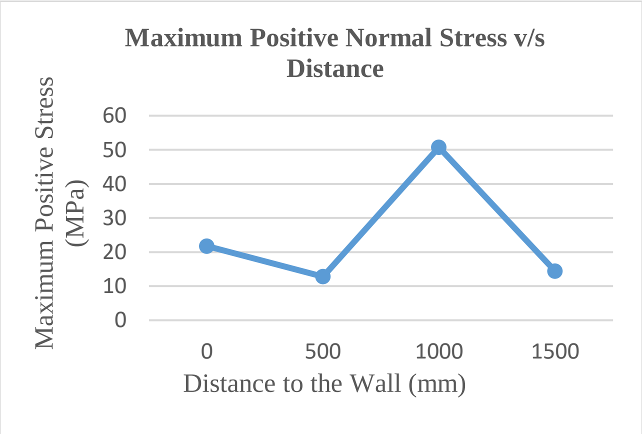


Fig. 4. A Plot showing Maximum Positive Normal Stress v/s Distance to the Wall

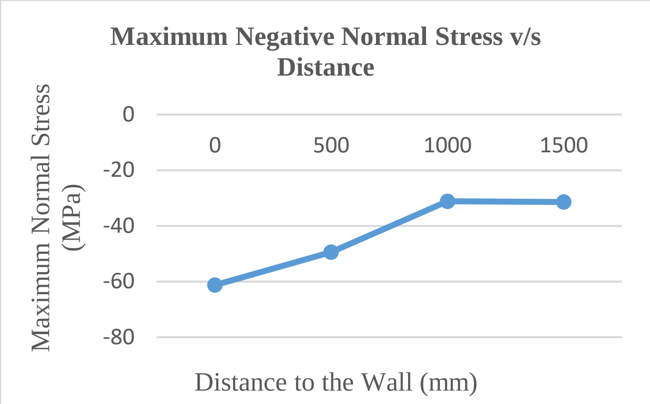


Fig. 5. A Plot showing Maximum Negative Normal Stress v/s Distance to the Wall

The positive normal stress was found to be varying in an irregular manner. The negative normal stress was found to be increasing and then remain almost constant for 1000mm and 1500mm eccentricity from the center of the wall.

## IV. LONG CARBON FIBRE MODEL

The study was conducted for meandering wall made of concrete with Long Carbon Fibre. Long Carbon Fibre is a twined, 48K, polypropylene backbone carbon fibre with an optimized application of 100 mm long fibres and a dosage rate of 1% by volume. The maximum positive deformation, maximum negative deformation, maximum normal stresses and maximum negative normal stresses are obtained as shown in Table 3.

Table 3. Consolidated Results

| Distance from Centre (mm) | Maximum Positive Deformation (mm) | Maximum Negative Deformation (mm) | Maximum Positive Normal Stress (MPa) | Maximum Negative Normal Stress (MPa) |
|---|---|---|---|---|
| 0 | 18.972 | -214.77 | 2.3523 | -3.5852 |
| 500 | 8.2181 | -139.11 | 0.79059 | -3.8518 |
| 1000 | 6.58 | -152.19 | 1.3056 | -4.8625 |
| 1500 | 9.9788 | -153.29 | 2.1151 | -6.3561 |

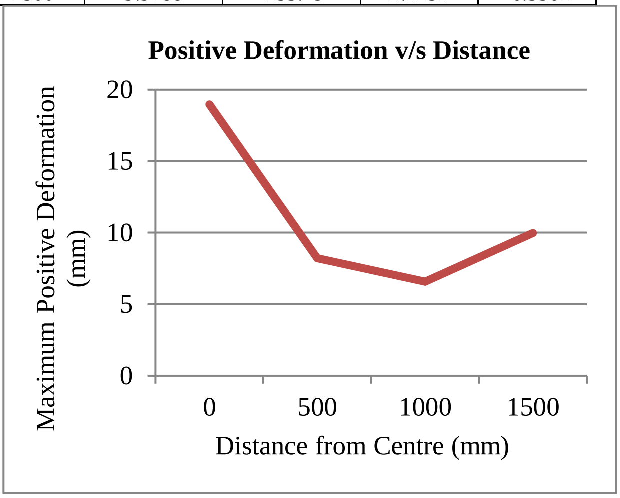


Fig. 6. Plot of Positive Deformation v/s Distance

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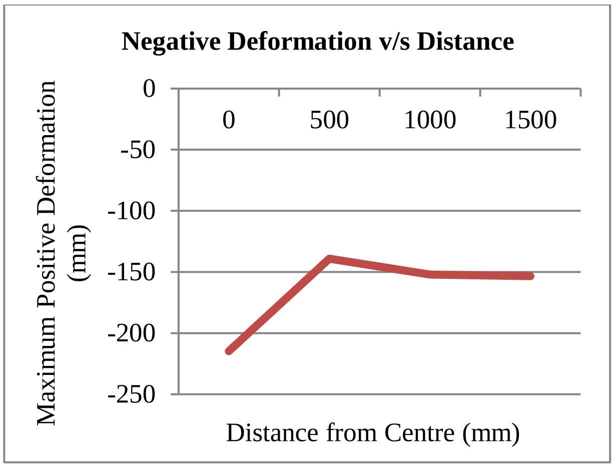


Fig. 7. Plot of Negative Deformation v/s Distance

The maximum positive deformation was found to be initially decreasing and then slightly increasing. The maximum deformation was found at the point of zero eccentricity from the center of the wall. Negative deformation was found to be first increasing and then decreasing.

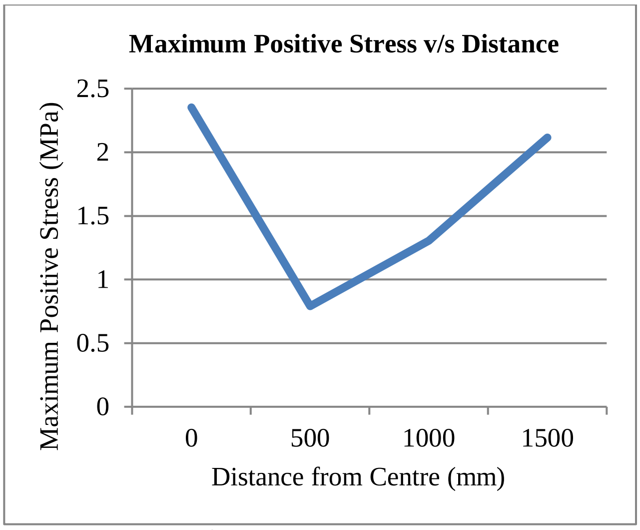


Fig. 8. Plot of Maximum Positive Stress v/s Distance

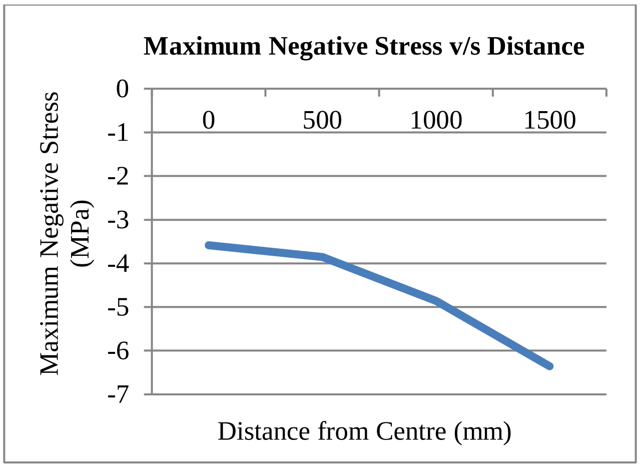


FiG. 8. Plot of Maximum Negative Stress v/s Distance

The positive normal stress was found to be first decreasing and then increasing. The negative normal stress is found to be gradually decreasing with respect to distance.

## V. INTERPRETATION OF RESULTS

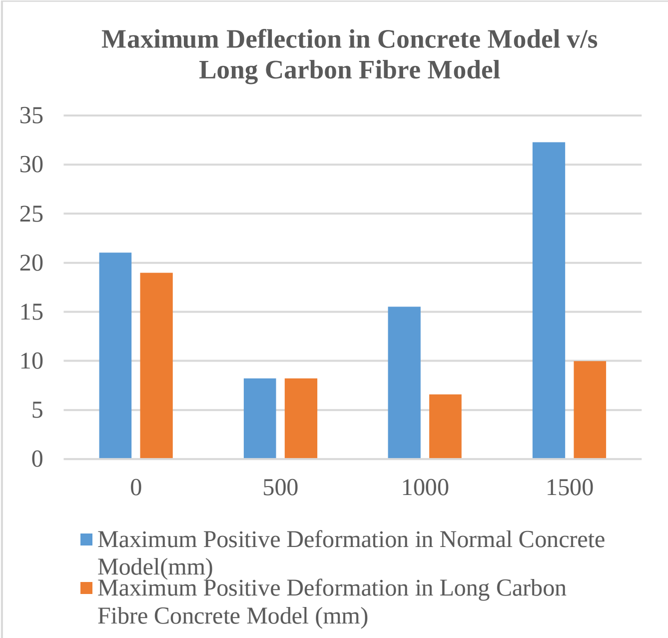


Fig. 9. Plot of Maximum Deflection in Normal Concrete v/s Maximum Deflection in Long Carbon Fibre Model

The maximum deflection at detonation points 0mm, 500mm, 1000mm and 1500mm was found to be decreasing while introducing long carbon fibre into the concrete. At eccentricity 0mm, there is a small reduction in deflection. At 500mm eccentricity, the deflection remains almost the same while at eccentricity 1000mm, there is a considerable reduction in deflection. The maximum reduction in deflection is found between the detonation points 1000mm and 1500mm.

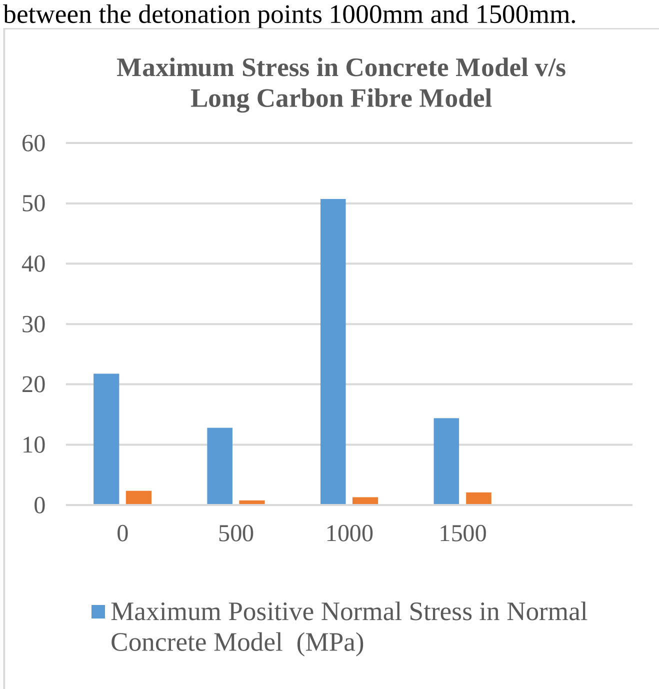


Fig. 10. Plot of Maximum Stress in Normal Concrete v/s Maximum Stress in Long Carbon Fibre Model

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The maximum stress at detonation points 0mm, 500mm, 1000mm and 1500mm was found to be decreasing while introducing long carbon fibre into the concrete. At eccentricity 0mm and 500mm there is a reduction in deflection. There is a considerable reduction in deflection at eccentricity 1000mm. The maximum reduction in deflection is found between the detonation points 1000mm and 1500mm.

## VI. CONCLUSIONS

It was found that deformation of the concrete wall was decreased with addition of long carbon fibre in to the concrete in resisting the blast load. For a concrete wall without long carbon fibre, the maximum deformation is when the detonation point is kept at an eccentricity of 1500mm with the center of the wall and is 32.29mm whereas in case of concrete wall with long carbon fibre, the maximum deformation was reduced to 9.98mm at the same detonation point. Similarly the normal stresses were also considerably reduced in case of concrete wall with long carbon fibre. In case of normal concrete, the maximum stress is at an eccentricity 1000mm and is 50.72MPa whereas in case of long carbon fibre the stress was reduced to 1.30MPa.

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