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# Experimental Research on Wave Changing of Rapid Assembling Anti-blast Walls

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# Experimental Research on Wave Changing of Rapid Assembling Anti-blast Walls

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**Abstract.**In order to research the ability to weaken the shock wave of the rapid assembling anti-blast walls, the shell explosion test was utilized to compare the shock wave overpressure peak in front of and behind the wall at different scaled distances. The overpressure suppression effect coefficient which reflects the wave dissipating performance of the anti-blast wall was put forward, and the effects of scaled distance, scaled wall height and scaled distance behind the wall on the wave dissipating performance were analysed with the experimental data. The results show that the value of reflected pressure is about 10 times the maximum value of diffraction overpressure, the scaled distance and the measuring distance behind the wall have a great effect on the diffraction overpressure; the diffraction overpressure behind the wall is significantly lower than the free field overpressure when there is no wall, and the overpressure suppression effect of the anti-blast wall can up to 50% or more; the scaled distance and the scaled wall height commonly affect the wave dissipating performance of the anti-blast wall. With the increase of the scaled distance behind the wall, the overpressure suppression effect coefficient gradually decreases. The research results can provide reference and basis for determining the safety distance of the target behind the anti-blast wall.

## 1. Introduction

At present, the anti-blast wall has become a research hotspot in the field of protective engineering, and it is an effective measure for the temporary protection of the battlefield and the important target. By setting an anti-blast wall in a certain distance outside the important target, the impact of shock waves and fragments will be effectively reduced, the destruction of the equipment and the probability of casualties will also be reduced. Rapid assembling anti-blast wall can quickly build a protective barrier in the periphery of the target, through the direct reflection of the air shock waves, their own deformation and packing of the scattering, friction absorption and consumption of explosive shock wave energy to achieve the purpose of protection.

In recent years, domestic and foreign scholars have carried out extensive research on anti-blast walls by experimental research [1-2], theoretical analysis [3-4] and numerical calculation [5-7]. Mu Zhaomin et al. [8] combined numerical simulation and experimental methods to study the impact of the shock wave on the anti-blast wall and the flow laws of shock wave, and analyze the internal mechanism of blast as well as the distribution of flow field around the anti-blast wall. Zhang Yao et al. [9] simulated the suppression effect of two kinds of anti-blast walls by using AUTODYN software and compared their suppression performance. The impact wave of two kinds of explosion-proof walls is simulated by using AUTODYN software. Hongwu et al. [10] studied the overpressure distribution after non-erect rigid anti-blast wall by using AUTODYN software and pointed out that walls with different tilt show similar suppression effect .

Numerical simulation methods are widely used in the previous studies, and the explosion tests are mostly shrinkage ratio or small equivalent close test. Currently, there's few research on the prototype test of rapid assembling anti-blast walls. In this paper, the shell explosion test was utilized to compare the shock wave overpressure peak in front of and behind the wall at different scaled distances with the value of overpressure calculated by the CONWEP program when there's no wall so as to analyze the rapid assembling anti-blast wall's ability to weaken the shock wave.

## 2. Test Overview

### *2.1 Test components*

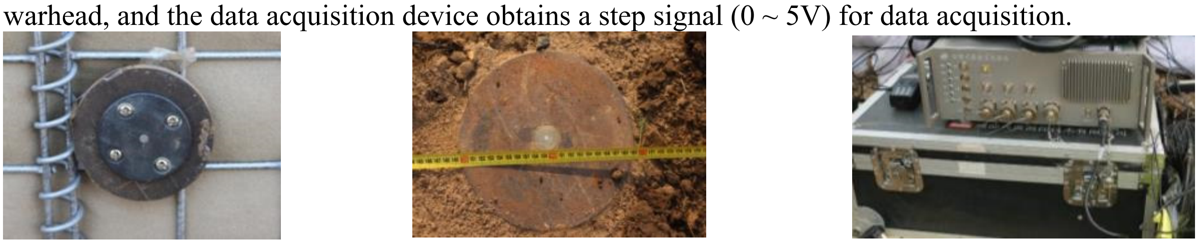
The structural framework of rapid assembling anti-blast wall are built with low-carbon steel wire, through the spiral hinges the wires are assembled into a removable, reusable steel mesh, and lined with high-tensile high-quality geotextile to be filled into a cubic wall, as shown in Fig.1. Shells used in this research are 122mm, 130mm, 152mm high explosive bomb filling with TNT, explosive loads are 3.2kg, 3.5kg, 5.8kg, as shown in Fig.2.

Fig 1. Anti-blast Wall Unit

Fig 2. Test Shell

### *2.2 Measurement system and equipment*

Pressure sensors are adopted in the test to measure the shock wave overpressure in front of or behind the wall, as shown in Fig.3 (a), (b). Reflective overpressure sensors are different range of Kistler sensors with the advantages of bandwidth, high sensitivity, simple circuit, low drift and stable performance. The output signal of the sensor is voltage. Tian'ao SC56671 portable data acquisition equipment is utilized as a collector (as shown in Fig.3(c)), the sampling rate is 2MHz, negative delay is 250ms, sampling time is 2s. In the test, the data acquisition system adopts the off-target external trigger mode, and the target is wound around the warhead, and the warhead strikes the target after the warhead, and the data acquisition device obtains a step signal (0 ~ 5V) for data acquisition.



(a) Sensor on the blast side (b) Ground sensor behind the wall (c) Data Acquisition Equipment

Fig 3. Pressure sensor and equipment

### *2.3 Test Arrangement*

The layouts of anti-blast walls of different specifications are as shown in Fig.4. In the static blast experiment, each shell are shot against the anti-blast walls with a distance of 5m, 10m and 15m, respectively, and the walls are arranged to ensure that the center of each wall and explosion center are on a straight line and the explosion wave can be exposed to all the wall surfaces. The overpressure in the center of the blast side of wall 1 #, 2 #, 4 #, 5 # and one unit length behind, 0.5m, 1.5m and 3.0m behind the wall are tested respectively. The position of overpressure measurement point is shown in Fig.4.

1 shot of 122mm detonator, 1 shot of 130mm detonator and 2 shots of 152mm detonator are triggered at the explosion center. Among them, 1 shot of 152mm detonator is buried in a shallow position, projectile level placed, axis of the projectile parallel to wall 1#, the top of the projectile is 0.08m from the ground, the others are placed vertically on the bouncer, keeping their burst center 1m from the ground.

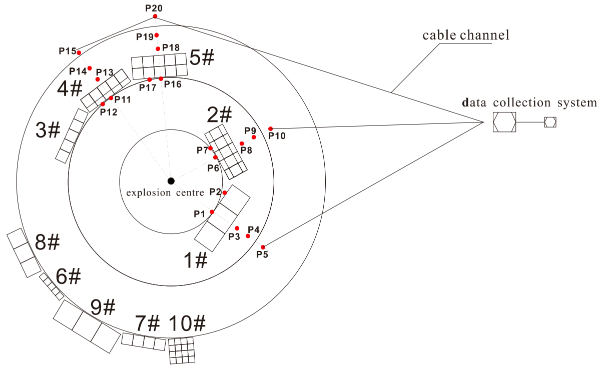



Fig 4. Test layout

## 3. Test results and analysis

At present, the researchers mainly use shock wave pressure, overpressure peak and other parameters to describe the spread of blast shock wave, and these parameters are generally expressed by the scaled distance. The scaled distance is defined as:

$$\overline{R} = \frac{R}{\sqrt[3]{C}} \tag{1}$$

Where R refers to the distance between the measuring point and the explosive center, m; C is the equivalent of TNT dose, kg.

### *3.1Shock wave field around the anti-blast wall*

This paper compared the overpressure peaks of the anti-blast walls at different scaled distances. Table 1 shows some of the overpressure peak results at different scaled distances.

Table 1. Peak Overpressure of Blast Wave

Unit: MPa

| Scaled Distance $\overline{R}$ /(m/kg1/3) | Blast Side | 0.5m behind the wall | 1.5m behind the wall | 3.0m behind the wall |
|---|---|---|---|---|
| 2.78 | 0.1714 | 0.0088 | 0.0080 | 0.0093 |
| 3.29 | 0.1090 | 0.0071 | 0.0078 | 0.0089 |
| 5.57 | 0.0775 | 0.0061 | 0.0060 | 0.0062 |
| 6.79 | 0.0364 | 0.0063 | 0.0060 | 0.0070 |

As can be seen from Table 1, due to the existence of anti-blast wall, the reflected pressure is about 10 times the maximum value of diffraction overpressure, which shows that the anti-blast wall have a great effect on the diffraction overpressure. The distribution of the shock wave behind the anti-blast wall is obviously different from that of the free field. In the test area, when the scaled distance $\overline{R}$ is a large value, the peak value of the shock wave overpressure increases with the distance $R_2$, while in free field, the peak value of shock wave overpressure decreases with the increase of distance. However, when the scaled distance $\overline{R}$ is a small value, the distribution law changes, the large value of shock wave overpressure peak are tend to be found near the wall, while the overpressure peak measured at the measurement point near the wall shows few difference. It can be seen that the existence of anti-blast wall will change the law of air shock wave propagation and the distribution of flow field, and this law of the distribution of the flow field is different at different scaled distance.

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*3.2 Suppression effect of anti-blast wall*

The suppression effect of the anti-blast wall on the shock wave directly determines the protective performance of the wall, which is of great significance to the study of the safety protection and fortification of the important target. Therefore, the suppression effect coefficient of the rapid assembling anti-blast wall is defined as WP to analyze the suppression effect of rapid assembling anti-blast wall, the suppression effect coefficient is calculated as:

$$W_P = \frac{\Delta P_0 - \Delta P_b}{\Delta P_0} \tag{2}$$

Where $\Delta P_b$ indicates the overpressure behind the wall when there's an anti-blast wall, $\Delta P_0$ indicates the overpressure when there's no anti-blast wall.

It can be seen from the test results that the overpressure behind the anti-blast wall is closely related to the scaled distance behind the wall. The scaled distance is defined as:

$$\bar{R}_2 = \frac{R_2}{\sqrt[3]{C}} \tag{3}$$

Where: R2 refers to the distance from the measure point to the anti-blast wall, m; C refers to the explosive load, kg.

It can be seen from formula (2) that the overpressure suppression coefficient increases with the decrease of the overpressure $\Delta P_b$ after the wall. Through explosion test, the variation law of the wave effect coefficient can be found, combined with the empirical formula of the overpressure and impulse of the blast wave in the free field, the shock wave overpressure $\Delta P_b$ can be calculated based on the calculation formula of the wave effect coefficient.

In order to study the suppression effect of the anti-blast wall, the overpressures of same measured point with or without anti-blast wall in the static explosion test are calculated by the CONWEP program. Table 2 shows the overpressure peak measured in static explosion test without anti-blast wall, and the scaled distance is $R_1$.

Table 2. Free Field Overpressure Peak calculated by CONWEP Program

Unit: MPa

| Scaled Distance $\bar{R}$/(m/kg1/3) | 0.5m behind the wall | 1.5m behind the wall | 3.0m behind the wall |
|---|---|---|---|
| 2.78 | 0.0969 | 0.0756 | 0.0562 |
| 3.29 | 0.0694 | 0.0554 | 0.0423 |
| 5.57 | 0.0390 | 0.0347 | 0.0297 |
| 6.79 | 0.0290 | 0.0260 | 0.0225 |

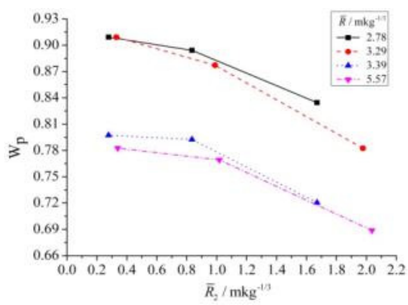
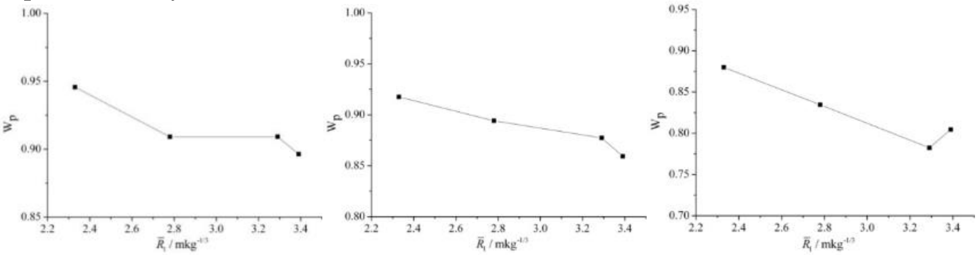



Fig 5. Variation curve of WP at different scaled distance $\bar{R}_2$

By comparing the data in Table 1 and Table 2, it can be found that when there's anti-blast wall, the peak value of overpressure is obviously smaller than that of the free-field at the same location when there is no anti-blast wall. According to the data in the table, combined with the formula (2), the overpressure effect coefficients WP of different anti-blast walls (at different scaled distance) are calculated, and Fig.5 shows the Variation curve of WP at different scaled distance $\bar{R}_2$. It can be seen from Fig.6 that at different scaled distance WP decreases with the increase of scaled distance $\bar{R}_2$, which indicates that the suppression effect of the quick-assembling anti-blast wall is weakened with the increase of the distance $R_2$.

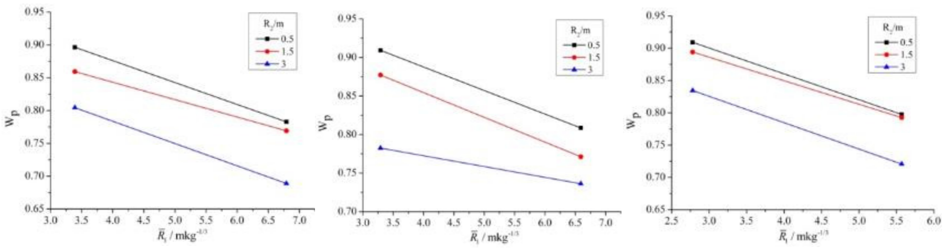
It can be seen from Fig.5 that both the scaled distance and the scaled wall height will affect the wave dissipating performance of the anti-blast wall. According to the data in Table 1 and Table 2, the variation curve of WP at different scaled distance $\bar{R}_1$ when the collapse distance is 5m is calculated by using formula (2), as shown in Fig.6. The change in the scaled distance is achieved by changing the explosive equivalent only and other conditions remain the same.




(a) 0.5m behind the wall (b) 1.5m behind the wall (c) 3m behind the wall

Fig 6. Variation curve of WP at different scaled distance $\bar{R}_1$

It can be seen from Fig.6 that when the explosive equivalent is changed, the variation of suppression effect coefficient WP of three measure point are pretty much the same, which shows that scaled distance $\bar{R}_1$ has little impact on WP. When the scaled distance is 5m, the overpressure effects of the three points after the wall are basically maintained at 91%, 87% and 80%. According to the data in Table 1 and Table 2, the Variation curve of WP at different scaled distance $\bar{R}_1$ is obtained by the formula (2), as shown in Fig. 6. The change in the scaled distance is achieved by changing the distance only and other conditions remain the same.




**(a)** $C = 3.2kg$ **(b)** $C = 3.5kg$ **(c)** $C = 5.8kg$

Fig.7 Variation curve of WP at different scaled distance $\bar{R}_1$

It can be seen from Fig. 7 that when the distance is changed, the overpressure suppression effect coefficient of the three points shows obvious difference. With the increase of the scaled distance $\bar{R}_1$, the overpressure elimination effect coefficient WP is reduced. When the explosive equivalent is 3.2kg and the scaled distance (m/kg1/3) increases from 2.78 to 5.57, WP of the three measure point drops from 90%, 86%, 80% to 78%, 77%, 69%, respectively, showing that the anti-blast wall has significant suppression effect on the shock wave overpressure .When the scaled distance is constant, WP increases with the decrease of $R_2$, indicating that the suppression effect is better in close distance.

Based on the above analysis, it is found that the variation law of overpressure suppression effect coefficient WP with scaled distance $\bar{R}_1$ shown in Fig.7 and Fig.7 are slightly different. The reason is that when the explosive equivalent changes, the height of the anti-blast wall also changes. WP is affected by the equivalent of explosives as well as wall height. As the increase of scaled distance, the wall height changes correspondingly. with the proportion of the increase in the proportion of the proportion of wall height also increased accordingly. It has been found in literature [11] that when the scaled distance is constant, with the increase of scaled wall height, the overpressure behind the anti-blast wall gradually decreases. According to Fig.6, 7, we can see that the proportion of the burst and the proportion of high-impact changes in the wall and the occurrence of a certain offset each other, so this time the magnitude of the change is not consistent with the literature. Wall height ratio is defined as:

$$\bar{H} = \frac{H}{\sqrt[3]{C}} \tag{4}$$

Where: H indicates the height of the anti-blast wall, m; C indicates the explosive load, kg.

## 4. Conclusion

1) The value of reflected pressure is about 10 times the maximum value of diffraction overpressure, the scaled distance and the measuring distance behind the wall have a great effect on the diffraction overpressure;

2) The overpressure suppression effect of the anti-blast wall can up to 50% or more, but with the increase of the scaled distance behind the wall $\bar{R}_2$, the overpressure suppression effect coefficient WP gradually decreases, and the wave dissipating performance of the anti-blast wall is weakened;

3) The scaled distance and the scaled wall height commonly affect the wave dissipating performance of the anti-blast wall. The wave dissipating performance cannot be determined simply relying on the scaled distance.

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