Performance and Application of Rapid Assembling Anti-blast Wall

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Abstract. With too much emphasis being laid on the antiknock performance of the current anti-blast wall and its mobility thus ignored, in order to strengthen the temporary protective capability of battlefield, a kind of rapid assembling anti-blast wall is proposed, its structural form and assembly method are introduced. The antiknock ability and the durability performance of the anti-blast wall are fully analyzed with the latest application cases, its application in military and civil field are introduced. The application results indicate that the anti-blast wall shows flexible mobility in transportation and assembling, moreover exhibit high adaptive capability, as well as protective capability. So it possesses great value in further research and promotion, and strengthening the combination with other protective technologies is considered to be the future trend.

1. Introduction

In recent years, with the strength of China’s military force, the demand for foreign economic interests increases sharply. In order to safeguard national interests, important military objectives such as oil fields developed abroad and ports leased by China are in urgent need of effective protection. On the other hand, terrorist bombings, especially car bombs, have put China's embassies abroad and peacekeeping force camps and other important targets under great potential threat and anti-terrorism pressure. For example, the Embassy in Kyrgyzstan was attacked by terrorists in September 2016.

The research on anti-blast walls at home and abroad mainly starts from the aspects of different structural forms [1-3], different loads and designs [4], etc. They study the protective performance of various anti-blast walls through experiments and numerical simulation [5], which has made good research progress and results. Although the shape and materials of the anti-blast walls vary, according to the mechanism of action, the anti-blast walls can be divided into three types: rigid anti-blast walls, flexible ones and inertial ones.

In this paper, a similar rapid assembly type anti-blast wall is introduced, its structural performance, assembly method and application research are summarized, and the next improvement design thinking is put forward according to the current application situation.

2. Introduction of rapid assembling anti-blast wall

2.1. Structure form

Rapid assembling anti-blast wall is a kind of prefabricated component, which adopts modular production, modular transportation and modular assembly construction. The wall structure unit is composed of a skeleton of low carbon steel wire welding, lined with high tensile high-quality geotextile, assembled
and connected into a dismountable and reusable steel mesh, and then filled to form a hexahedral wall, as shown in figure 1. (a). The wall filling materials can be sand, soil, gravel or even construction waste, etc., to improve the assembly efficiency. In operation, the construction machinery can be used with a small number of personnel to quickly load. After the completion of the task, due to the lack of geotextile at the bottom of the anti-blast wall unit, the machine can be used for rapid recovery of steel mesh, with the characteristics of economy, saving, environmental protection, no pollution.

The units of the anti-blast wall are connected by screw hinges and bolts, and the connection can rotate freely to facilitate folding for storage and transportation, which greatly increases the utilization of space. There are mainly two folding methods, as shown in figure 1. (b) and (c).

![Figure 1. A kind of rapid assembling anti-blast wall](image)

2.2. Assembly method

Compared with other types of anti-blast walls, the rapid assembling anti-blast walls have faster assembling speed and less personnel required, which can greatly improve the construction efficiency by cooperating with small machinery and equipment. The assembly method is mainly manual assembly, which is suitable for setting small volume short-distance anti-blast wall.

Proved by the test, a set of 5.3 m long, 1.37 m high, and 1.06 m rapid assembling anti-blast wall can be assembled within 18 minutes by only two people and a small excavator. And it takes 10 workers 7 hours to build a sandbag wall of the same volume (about 1500 sandbags). The time efficiency is increased by 116 times. The assembly steps are shown in figure 2. When large and long distance anti-blast walls need to be set up, pre-connected anti-blast wall units can be loaded into ISO standard custom shipping containers and deployed with trailers during assembly. According to the measured data, two people and a trailer can lay a set of 333 m long, 2.21 m high and 2.13 m thick explosion wall in less than 1 minute.

![Figure 2. Manual assembly method](image)

3. Performance research and analysis

3.1. Anti-blast performance

The steel mesh wire diameter of the rapid assembling anti-blast wall is 4 mm or 5 mm, and the welding spot has a high tensile capacity. Also, the geotextile adopted has a large breaking strength, and the wall can effectively resist the invasion of broken shrapnel. On the other hand, depending on its own weight and the effective connection between units, the wall forms an integral structure, which can effectively resist the effect of explosion shock wave with the flying energy dissipation of packing. Table 1 shows the technical parameters of rapid assembling anti-blast walls. The structural strength and stiffness of the
blast wall depend on the packing in the member, which is restrained by wire and geotextile. At present, the explosion test of the explosion proof wall has been carried out.

Table 1. The technical parameters of rapid assembling anti-blast wall

| Project                  | Performance | Performance parameters |
|--------------------------|-------------|------------------------|
| Wire mesh performance    |             |                        |
| Length of wire mesh      | 75±2 mm     |                        |
| Width of wire mesh       | 75±2 mm     |                        |
| Solder joint resistance  | ≥3.5 kN     |                        |
| Geotextile performance  |             |                        |
| Mass per unit area       | 300±20 g/m² |                        |
| Longitudinal fracture strength | ≥4.2 kN/m   |                        |
| Transverse fracture strength | ≥5.5 kN/m  |                        |
| CBR bursting strength    | ≥0.65 kN    |                        |

In 2013, a unit conducted static explosion test with rapid assembling anti-blast walls 1.06 m thick, 1.37 m high and 4.24 m long. The total yield of ammunition is equivalent to 3.5 kg TNT explosive, and the distance between the wall and the explosive is 3 m. The two anti-blast walls are filled with three different fillers, namely stone, sand and earth. It is proved by tests that the wall unit filled with stones is basically intact, and the geotextile on the blasting surface is obviously damaged. However, no overturning of the wall is seen, and no shrapnel injection is seen behind the wall. The steel mesh has a small deformation, as shown in Figure 3. (a). For the wall filled with sand and soil, no overturning was seen on the wall, and no shrapnel injection was seen behind the wall. Furthermore, no damage was seen on the ammunition box behind the wall. However, the bottom deformation was large and the filling was inflated, as shown in Figure 3. (b).

(a) Cobble filled wall  (b) Sand and soil filled wall

Figure 3. Stationary explosion experiment

At the beginning of 2016, a unit in Ningxia used rapid assembling anti-blast walls for Eod protective. The total yield of ammunition is equivalent to 10.1 kg TNT explosives. The test adopts anti-blast wall units with unit dimensions of 0.75 m thick, 2.21 m high and 0.75m long to combine into walls of 2.25 m thick, and bolts are used to connect the units. At a distance of 1 meter from the bomb, the wall is shaped like a pin and surrounds the bomb with pressure relief joints, as shown in Figure 4. (a). The test shows that the rapid assembling anti-blast wall has good anti-blast performance. After the explosion, the whole wall shifted backwards and tilted, but no overturning was observed. The steel mesh and geotextile on the face of detonation were damaged. Part of the first anti-blast wall unit collapsed, but other walls remained intact and no shrapnel was seen piercing through behind the wall, as shown in Figure 4. (b).

(a) Arrangement of anti-blast wall before experiment  (b) Destruction of anti-blast wall after experiment

Figure 4. Explosive disposal experiment
3.2. Durable performance

In 2011, a military academy used rapid assembling anti-blast walls of 1 m thick, 1 m high and 1 m long as important equipment for protection, as shown in Figure 5. (a). In 2016, a second inspection of the anti-blast wall built by the college in 2011 found that the wall is still relatively intact and there are weeds growing on the upper part of the wall stuffing. Although the geotextile on the side of the wall is damaged and the steel mesh is rusted, there is no overall fracture of the geotextile and deformation of the steel mesh. Therefore, it still has high tensile strength, as shown in figure 5. (b). It can be seen that the anti-blast wall can be used for at least five years and still has basic protective functions.

After the technological improvement, the low-carbon steel wire mesh that constitutes the skeleton of the anti-blast wall has undergone a strict "zinc bath" process, and its galvanization amount reaches 250 g/m², which makes the grid structure more corrosion resistant than electroplated steel. The geotextile forming the wall surface has flame retardancy and increases anti-ultraviolet function. While ensuring a reasonable price, it also enhances its anti-aging ability. For long-term use of such anti-blast walls in high-temperature and high-salt environments such as South China Sea and reefs, cement grout can be sprayed on the surface of the wall unit to improve its durability.

![New constructed barrier](image1)
![Condition of side](image2)

Figure 5. Detection of durability

4. Applied research analysis

4.1. Military applications

Rapid assembling anti-blast wall has advanced features such as easy to carry, quick to install, diverse colors, varied structure and quick withdrawal, etc. On the other hand, the anti-blast wall can provide effective protection for warfighters and equipment, and has strong protection capability. The anti-blast wall has a variety of models and modules, which are suitable for different protection requirements. Different models can also be combined freely to form ammunition depot, shooting range, sentry post, barracks and other military fortifications to meet different functional requirements.

At present, the Egyptian Red Sea Fleet has used rapid assembling anti-blast wall units of 1.52 m thick, 2.21 m high and 1.52 m long to surround the barracks and set up sentry posts, providing effective protection for equipment and personnel in the barracks, as shown in figure 6. (b).

![Pyramid structure](image3)
![Camp fence](image4)

Figure 6. Military application

4.2. Application in the civil domain

The rapid assembling anti-blast walls are also applicable to civil engineering. Due to its reasonable protection function and price, the blast wall has been gradually used by the government and related departments to prevent terrorist attacks. At present, the anti-blast wall has been used by public security
departments in China to protect and expel the suspected explosives, and good results have been achieved.

In recent years, there have been frequent natural disasters, especially floods and debris flows, which have posed great threats to people's lives and property safety. Because the flood wall (rapid assembling anti-blast wall with waterproof material) is easy to install, and the filler can be taken from local materials such as sand, stones, silt, it can replace traditional sandbags, avoiding the inefficiency of traditional flood fighting and rescue by relying on manpower to stack sandbags, which greatly improves the efficiency of embankment construction during floods (see figure 7). In July 2016, China's Wuhan sudden massive flood, the rapid assembling anti-blast wall has been partially applied and achieved good results.

![Figure 7. Temporary flood wall](image)

5. Conclusion
1) The study on rapid assembling anti-blast walls is of great significance for developing the protection of troops and equipment for field training in wartime and unexpected situations, and for improving the combat effectiveness of troops. It has great research and promotion value and great benefits.

2) At present, the explosion tests of rapid assembling anti-blast walls mostly focus on the static explosion study of small equivalent. The next research direction should focus on the explosion impact tests of car bombs, and study the anti-explosion performance of the anti-blast walls with different assembly forms, so as to further optimize the structure and assembly form of the anti-blast walls.

3) The author thinks that the technology and research of rapid assembling anti-blast wall should be combined with other protection technologies, so as to improve the survivability of the protection project and better meet the needs of future wars, which is also the focus of the next research.

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