

BOLLARD SYSTEM AND METHOD OF INSTALLATION

Field of Invention

5 The present invention relates to an anti-ram bollard assembly and deployment of multiple bollard assemblies to arrest vehicular attacks, and to prevent penetration of the vehicle.

Background of the Invention

10 In recent years for security reasons, many prominent establishments such as government buildings, embassies, convention centres, public transportation hubs and other perceived terrorist targets have been equipped with barrier systems to protect the establishments from vehicle attacks. Especially if the vehicle is heavyweight or moving at high speeds or carrying explosives, the attack can cause extreme destruction.

15 Various barrier systems have since been employed with the intention of protecting buildings and structures from attacks. Metal or concrete barriers may be erected around a building to obstruct vehicular penetration. In order to resist large impacts from speeding heavy vehicles, the barriers have to be massive, resulting in a less aesthetic system.

20 Barrier systems employing bollards may be more aesthetic. However, due to their small form factor and weight, conventional bollards are useful primarily as a barrier. In order to resist large impacts, the conventional bollards usually require large and deep bases, and deep excavations to anchor their bases. Because utilities transmission such as electricity lines, water pipes and communications lines are often buried underground, deep excavation to install bollards is costly and time-consuming. In addition, deep
25 excavation causes disruption to utility services, inconvenience to pedestrian traffic, and often results in a less aesthetic landscape.

Summary of the Invention

Embodiments of the invention relate to an anti-ram bollard assembly and a barrier installation comprising a plurality of anti-ram bollard assemblies to prevent vehicles from penetrating the barrier installation.

Embodiments of the invention are particularly advantageous as the bollard assemblies may be installed in shallow trenches without the need for deep excavations that may disrupt various utility lines buried in the ground. The depth of such trenches may be about 1.00 m or less. Yet, the impact rating (i.e. maximum impact loading) of the bollard assemblies may be improved over conventional bollards of similar form factors. This may be achieved by various features as hereinafter described.

Each bollard assembly comprises a base assembly, a bollard member attached to the base assembly and a reinforcement member attached to the base assembly which extends generally in a direction substantially perpendicular to the bollard member. The bollard assemblies may be constructed in various ways, including but not limited to the following. The base assembly may include an I-beam arrangement to which a lower end of the bollard member may be attached. The bollard member may be a hollow structure to receive a fill material therein upon installation to increase a mass of the bollard assembly. The reinforcement member may have a length greater than the length of the base assembly. The bollard assembly may be constructed and arranged to receive rebars to connect adjacent bollard assemblies.

A plurality of bollard assemblies may be deployed to form a cohesive installation. The plurality of bollard assemblies may be arranged at a predetermined distance apart and connected by rebars to provide an enlarged effective base area for stabilizing the installation when an impact is received. If an impact is expected from a particular direction striking a first side of the bollard assembly, the reinforcement member of each bollard assembly may be arranged along generally the same direction and extending from

a second opposed side of the bollard assembly. The reinforcement member may include a free end spaced apart from other adjacent bollard assemblies.

A combination of these and other features are designed to increase the impact rating of a barrier installation without having to significantly increase the dimensions of the bollard assemblies. For example, the deployment of an I-beam arrangement is to enhance the strength of the base assembly. The bollard member is to receive a fill material which is designed to constrain movement of the bollard member when it is struck, thereby minimizing shearing of the bollard member.

Further, the reinforcement member attached to the base assembly and rebars connecting various bollard assemblies are to provide an effective impact load transfer. More specifically, when one or more bollard assemblies in an installation is struck by a vehicle, the impact force is transmitted from the bollard member down to the base assembly and is dissipated through the reinforcement members as well as the network of rebars connecting adjacent bollard assemblies. The arrangement of the reinforcement member on an opposite side of the bollard assembly in respect of an incoming impact is to counter the impact force which tends to topple the bollard member. The network of bollard assemblies connected by rebars provide an enlarged effective base area so that movement in one bollard assembly may be constrained by the rigid connection to adjacent bollard assemblies.

Other advantages will be apparent upon reading of the following detailed description and review of the associated drawings.

Brief Description of the Drawings

FIG. 1A is a perspective view of a bollard assembly according to one embodiment of the invention.

FIG. 1B is another perspective view of a bollard assembly of FIG. 1A.

FIG. 2A is a perspective view of the bollard assembly of FIG. 1A with a top plate of a base assembly removed.

5 FIG. 2B is a perspective view of the bollard assembly of FIG. 1B with a top plate of a base assembly removed.

FIG. 3 is a close-up view of a base assembly of FIG. 1B.

10 FIG. 4A is a perspective view of an installation comprising several bollard assemblies.

FIG. 4B is a perspective view of the installation of FIG. 4A having rebars.

15 FIG. 4C is a perspective view of the installation of FIG. 4B with the ground site removed.

FIG. 4D is a perspective view of the installation of FIG. 4B in a completed state.

20 FIG. 5A is a perspective view of a layout of rebars.

FIG. 5B is another perspective view of a layout of rebars.

25 FIG. 6A is a perspective view of a perimeter barrier installation provided with rebars.

FIG. 6B is a perspective view of the perimeter barrier installation of FIG. 6A in a completed state.

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Detailed Description

In the following description, numerous specific details are set forth in order to provide a thorough understanding of various illustrative embodiments of the present invention. It will be understood, however, to one skilled in the art, that embodiments of the present invention may be practiced without some or all of these specific details. In other instances, well known process operations have not been described in detail in order not to unnecessarily obscure pertinent aspects of embodiments being described. In the drawings, like reference numerals refer to same or similar functionalities or features throughout the several views.

Reference is made to FIGs. 1A and 1B which illustrate perspective views of a bollard assembly 1 according to one embodiment of the invention. The bollard assembly 1 comprises a base assembly 20, a bollard member 10 projecting from the base assembly 20 and at least one reinforcement member 30 attached to the base assembly 20.

The base assembly 20 may comprise one or more I-beam (or H-beam) cross-section arrangements, which in turn comprise a top plate 22, a bottom plate 24 and at least one intermediate plate 26 interposed therebetween. The intermediate plate(s) 26 may be fixedly attached to the top and bottom plates 22, 24 by welding to support the top and the bottom plates 22, 24. In the embodiment of FIGs. 1A and 1B, four intermediate plates 26 are provided in the base assembly 20 and disposed substantially perpendicular to one another. However, it should be appreciated that other number of intermediate plates 26 may be provided and may be disposed at other angles to one another. In the case where only two intermediate plates 26 are provided, the two intermediate plates 26 may be disposed at about 180 degrees with respect to each other. The I-beam arrangement is to provide reinforcement to the base assembly 20. More particularly, the intermediate plate 26 supports the top and the bottom plates 22, 24 to prevent deformation due to static loading prior to impact loading.

A bollard member 10 may be received in the base assembly 20 and integrated with the I-beam arrangement. More specifically, a lower end of the bollard member 10 may be arranged to be fixedly attached, such as by welding, to the top plate 22, the bottom plate 24 as well as the intermediate plates 26. Such an arrangement is to increase the strength and stability of the bollard assembly 1. Exemplary arrangements of FIGs. 2A and 2B illustrate the bollard assemblies of FIGs. 1A and 1B respectively with their top plates 22 removed. A lower end of the bollard member 10 is attached to a bottom plate 24 and supported by four intermediate plates 26 at the sides of the bollard member 10. It should be appreciated that other arrangements allowing the bollard member 10 to be integrated with the I-beam arrangement may be envisaged in other embodiments of the invention.

The bollard member 10 may be hollow to receive a heavyweight fill material which has high compressive strength, e.g., concrete, upon installation of the bollard assembly 1. The fill material is to add substantial mass to the bollard assembly 1 to reinforce the bollard member 10. Without a fill material in a hollow bollard member 10, the bollard member 10 is prone to deformation, bending and even shearing when the bollard member 10 is struck by a large impact. With the addition of a suitable fill material, the fill material absorbs part of the impact and constrains deformation of the bollard member 10 to prevent failure of the bollard member 10.

One or more reinforcement members 30 may be provided in the base assembly 20 to increase stability of the bollard assembly 1. When a vehicle strikes the bollard member 10, the impact force is transferred to the base assembly 20 and to the reinforcement members 30 to be dissipated to the surroundings, e.g. ground. A large base assembly 20 is therefore more capable of stabilizing the bollard assembly 1 when the bollard member 10 is struck by an impact. The reinforcement members 30 are to enlarge a base area provided by the base assembly 20 to increase stability of the bollard assembly 1. One end of the reinforcement member 30 may be attached to the base assembly 20 while a distant free end 32 extends away from the base assembly 20. In the embodiment of FIG. 3, six reinforcement members 30 are fixedly attached, such as by welding, to the

bottom plate 24 of the base assembly 20. While FIG. 3 illustrates the reinforcement members 30 as cylindrical rods, it should be appreciated that the reinforcement members 30 may take any other suitable forms. Although reinforcement members (first reinforcement members) 30 are illustrated as being attached to a bottom plate 24, additional reinforcement members (second reinforcement members) may be attached to the top plate 22 of the base assembly 20 but separate from the first reinforcement members (not shown). The reinforcement members 30 may have a length which is greater than a length of the base assembly 20, and a cross-section diameter or dimension which is substantially smaller than a height of the base assembly 20. These proportions are advantageous in reducing material costs. Variations to the reinforcement members 30 may be made depending on the impact rating required of the bollard assembly 1. Generally, to achieve higher impact rating, the number of reinforcement members 30, length of reinforcement members 30, cross-section area of reinforcement members 30, or a combination thereof may be increased.

The bollard assembly 1 according to embodiments of the invention may be connected to other bollard assemblies 1 to provide a cohesive installation which is capable of arresting large impact forces. To this purpose, intermediate plates 26 of each base assembly 20 may be perforated to receive rebars 104 there through to connect adjacent bollard assemblies together. Interconnection of several bollard assemblies 1 via the rebars 104 is described in greater detail in later paragraphs.

As compared to a conventional bollard, a bollard assembly 1 according to embodiments of the invention is capable of providing a same impact rating yet requiring a smaller form factor. An exemplary bollard assembly 1 according to an embodiment may have the following dimensions. The base assembly 20 may have a length (L_{BA}) of 0.50 m, a breadth (B_{BA}) of 0.50 m and a height (H_{BA}) of 0.175 m. The bollard member 10 may have a height (H_{BM}) of 1.20 m projecting from the top plate 22 of the base assembly 20, an outer diameter (D_{BM}) of 0.194 m and an inner diameter of 0.178 m. In an exemplary installation, several bollard assemblies 1 may be spaced apart by between

about 1.0 m to about 1.5 m. Accordingly, for this and other embodiments, the base assembly 20 may be installed within about 1.00 m below grade level.

Dimensions of various embodiments of a bollard assembly 1 are not limited to the above and may vary according to impact rating requirements and site conditions. Generally, to increase the impact rating of a bollard assembly 1, one of the following parameters or a combination thereof may be increased: dimensions of a base assembly 20 (including height, length and breadth), thickness of the plates forming the base assembly 20, dimensions of reinforcement members 30 (including length, diameter and cross-section area), and number of reinforcement members 30.

In FIGs. 1A, 1B, 2A and 2B, the base assembly 20 is illustrated as having a square cross-section and the bollard member 10 has a circular cross-section. It should be appreciated that the base assembly 20 and the bollard member 10 may have cross-sections of other shapes, including but not limited to, rectangle, square, circle, oval, triangle, and any other geometrical and non-geometrical shapes. Also, the bollard assembly 1 may be prefabricated and or assembled at the installation site using a high strength material including, but not limited to, steel. Prefabrication of the bollard assembly 1 is advantageous in providing reduced installation time and higher structure strength.

FIG. 4A is a perspective view of a perimeter installation comprising several bollard assemblies 1 of FIGs. 1A. A shallow trench 102 is provided in the ground in which several bollard assemblies 1 may be arranged therein and spaced apart from one another by a predetermined distance. In respect of the above exemplary bollard assembly 1 with a base assembly 20 having a height of about 0.20 m, the trench 102 required may have a height of between about 0.20m to about 1.00 m. The spacing of the bollard assemblies 1 would depend on the impact rating required of the installation.

The bollard assemblies 1 are arranged such that their reinforcement members 30 are disposed generally along a path expected of an impact but opposite the side of the

bollard assembly 1 receiving the expected impact. For example, if an impact is expected from a direction or path X towards a first side of a bollard assembly 1, the reinforcement members 30 may be disposed generally along direction or path X. The reinforcement members 30, however, are disposed on a second side (opposed to the first side) of the bollard assembly 1. When a vehicle traveling along direction X strikes the bollard member 10, the bollard assembly 1 tends to tilt in the direction of the impact. Without the reinforcement members 30 to stabilize the bollard assembly 1, a sufficiently large impact would topple the bollard member 10, dislodge the bollard assembly 1 and eventually allowing the attacking vehicle to penetrate. The reinforcement members 30, provided on a side of the bollard assembly 1 opposite to the expected impact, are to resist tensile and/or compression forces resulting from an impact, and thereby minimizing tilting and preventing dislodgement of the bollard assembly 1. The bollard assembly 1 may also be arranged such that free ends 32 of the reinforcement members 30 are spaced apart from adjacent bollard assemblies 1.

Impact rating of an installation of bollard assemblies may be further enhanced by connecting several bollard assemblies to provide a cohesive installation having an enlarged effective base area which in turn increases stability. To this purpose, one or more rebars 104 may be threaded through perforations 28 in the intermediate plates 26 of the base assemblies of adjacent bollard assemblies arranged at a predetermined distance from one another (see FIG. 4B). The rebars 104 may be removably arranged through the perforations 28, or may be fixedly attached, such as by welding to the bollard assembly 1, at the installation site. As illustrated in FIGs. 4B and 4C, a first plurality of rebars 104 are provided through intermediate plates 26 of adjacent bollard assemblies. A second plurality of rebars 104 may also be provided in a generally perpendicular directing intersecting the first plurality of rebars 104. As shown in FIGs. 4B and 4C, the various rebars 104 intersect the bollard assemblies to form a grid arrangement. The various rebars 104 and reinforcement members 30 and at least portions of the base assemblies 20 are encased in a bonding material, e.g., concrete to provide a reinforced foundation pad 106 for the installation 100 (see FIG. 4D). When one or more bollard assemblies in a completed installation 100 is struck by a vehicle, the enlarged base area formed by a

combination of the reinforcement members 30 and rebars 104 interconnecting various bollard assemblies provide a stable foundation to constrain movement of the bollard assemblies 1.

5 FIGs. 5A and 5B are various perspective views of possible layouts of rebars 104. As illustrated, certain rebars 104 may intersect base assemblies of the bollard assemblies while other rebars 104 may be spaced apart from the bollard assemblies.

10 A bonding material, e.g. concrete, may be provided in the trench 102 to anchor the installation to the site and to provide a reinforced concrete foundation pad 106. If it is desired to conceal the base assembly 20, the base assembly 20 and reinforcement members 30 may be encased in the bonding material. To this purpose, a layer of the bonding material, between about 2.5 cm to about 6.0 cm, may be provided above the base assembly 20 to conceal it. Alternatively, the bonding material may be suitably provided
15 to allow the top plate 22 of the base assembly 20 to be visible and substantially flush with an adjoining surface, e.g. ground. Optionally, various finishes, e.g., tiles or any other forms of paver materials may be disposed around the bollard member 10. A finished appearance of an installation comprising several bollard assemblies is illustrated in FIG. 4 in which the base assembly 20 is concealed while several bollard member 10 project
20 above a ground site to arrest impacts. Upon installation of the bollard assemblies, the bollard member 10 may be reinforced by filing with a rigid material with high compressive strength, e.g. concrete. FIG. 4D illustrates a completed installation 100 in which the top plate 22 of the base assembly 20 is substantially flush with an adjoining ground surface.

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 FIG. 6A is a perspective view of a perimeter barrier installation provided with rebars 104 prior to encasing in concrete. FIG. 6B is a perspective view of the perimeter barrier installation 100 of FIG. 6A in a completed state in an exemplary setting. Although FIG. 6 illustrates the installation as an array of bollard members 10, various
30 modifications may be made to the installation. For example, the installation may be part

of street furniture, e.g. lighting posts, signage posts, bus shelters, benches, planters and trash bins. This way, the installation may be rendered more aesthetic.

5 A general method of installing a plurality of bollard assemblies at a site is described as follows. The site is prepared by excavating a shallow trench 102 for receiving the bollard assemblies. Dimensions of the trench 102 would depend on a height required of the bollards, spacing between adjacent bollard assemblies as well as the dimensions of the base assembly 20 and reinforcement members 30. According to
10 embodiments of the invention, a depth of the trench 102 may range between about 0.20 m to about 1.00 m. Optionally, a leveling material, such as concrete, may be provided in the trench 102 to form a level surface for easy installation of the bollard assemblies 1. Subsequently, a plurality of prefabricated bollard assemblies 1 may be arranged in the trench 102, separated by a predetermined distance and with free ends 32 of their reinforcement members 30 spaced apart from adjacent bollard assemblies 1. Optionally,
15 a small amount of concrete may be provided at this stage to set the bollard assemblies 1 in position.

Rebars 104 may connect the plurality of bollard assemblies 1 by providing the rebars 104 through appropriate perforations 28 in the intermediate plates 26 of the base
20 assemblies 1. The number of rebars 104 and their arrangement would depend on site conditions as well as the desired impact rating required. A bonding material, such as concrete, is then provided to fill the trench 102 as well as to anchor the bollard assemblies to the site. If it is desired to conceal the base assembly 20, a layer of the bonding material may be provided above the top plate 22 of the base assembly 20. This
25 layer may range between 2.5 cm to about 6.0 cm but is not limited as such. Otherwise, if it is desired to have the top plate 22 of the base assembly 20 flush with an adjoining surface, the bonding material should accordingly be provided surrounding the top plate 22. The bollard member 10 may be filled with a rigid material of high strength, e.g. concrete. Optionally, paver materials may be installed around the bollard members 10.

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It is to be understood that other embodiments will be apparent to those skilled in the art from consideration of the specification and practice of the present invention. Furthermore, certain terminology has been used for the purposes of descriptive clarity, and not to limit the invention. The embodiments and features described above should be
5 considered exemplary, with the invention being defined by the appended claims.

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Claims

1. A bollard assembly comprising:
 - a base assembly having an I-beam arrangement, the base assembly providing a
5 base area;
 - a bollard member attached to the base assembly; and
 - a first reinforcement member attached to the base assembly and extending in a
direction substantially perpendicular to the bollard member to enlarge the base area.
- 10 2. The bollard assembly of claim 1, wherein the I-beam arrangement comprises:
 - a top plate;
 - a bottom plate; and
 - an intermediate plate supporting the top plate and the bottom plate, wherein the
top plate, the bottom plate and the intermediate plate are attached to the bollard member.
- 15 3. The bollard assembly of claim 2, wherein the first reinforcement member is attached
to the bottom plate.
4. The bollard assembly of claim 3, wherein the intermediate plate is perforated to
20 receive a rebar there through.
5. The bollard assembly of claim 4, wherein the bollard assembly further comprises a
second reinforcement member attached to the top plate and separate from the first
reinforcement member.
- 25 6. The bollard assembly of claim 5, wherein a length of the reinforcement member is
greater than a length of the base assembly.
7. The bollard assembly of claim 1, wherein the I-beam arrangement comprises:
 - 30 a top plate;
 - a bottom plate; and

a plurality of intermediate plates arranged at an angle with one another to support the top plate and the bottom plate, wherein the top plate, the bottom plate and the plurality of intermediate plates are attached to the bollard member.

5 8. The bollard assembly of claim 7, wherein the plurality of intermediate plates are perforated to receive a plurality of rebars there through.

9. The bollard assembly of claim 8, further comprises a second reinforcement member attached to the top plate and separate from the first reinforcement member, wherein the
10 first reinforcement member is attached to the bottom plate.

10. The bollard assembly of claim 1, wherein the bollard assembly comprises a steel material.

15 11. The bollard assembly of claim 1, wherein the bollard member is to receive a fill material therein to increase a mass of the bollard assembly.

12. The bollard assembly of claim 11, wherein the fill material is concrete.

20 13. An installation comprising:

a plurality of bollard assemblies disposed at a predetermined distance from one another, each of the plurality of bollard assemblies comprising:

a base assembly having an I-beam arrangement and providing a base area;

a bollard member attached to the base assembly;

25 a first reinforcement member attached to the base assembly to enlarge the base area; and

a plurality of rebars connecting the plurality of bollard assemblies.

14. The installation of claim 13, wherein the first reinforcement member includes a free
30 end spaced apart from an adjacent one of the plurality of bollard assemblies.

15. The installation of claim 14, wherein the I-beam arrangement comprises:

a top plate;

a bottom plate; and

an intermediate plate supporting the top plate and the bottom plate, wherein the
5 top plate, the bottom plate and the intermediate plate are attached to the bollard member.

16. The installation of claim 15, wherein the intermediate plate is perforated to receive the plurality of rebars there through.

10 17. The installation of claim 15, wherein a first side of the base assembly is to receive an impact and the first reinforcement member is disposed on a second opposed side of the base assembly.

18. The installation of claim 15, wherein the base assembly, the first reinforcement
15 member, and the plurality of rebars are encased in a bonding material.

19. The installation of claim 18, wherein the bonding material has a thickness between about 2.5 cm to about 6.0 cm above the base assembly.

20 20. The installation of claim 13, wherein a height of the base assembly is between about 0.20 m to about 0.50 m.

21. The installation of claim 13, wherein the bollard member is to receive a fill material to increase a mass of the bollard assembly.

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22. The installation of claim 21, wherein the fill material is concrete.

23. The installation of claim 13, wherein the base assembly is disposed within about 1.00 m below grade level.

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24. The installation of claim 13, wherein the plurality of the bollard members form part of a street furniture.

25. A method of installation, comprising:

5 forming a trench;

 arranging a plurality of bollard assemblies in the trench separated from one another, a first reinforcement member of each of the plurality of bollard assemblies having a free end spaced apart from an adjacent one of the plurality of bollard assemblies;

10 connecting the plurality of bollard assemblies with a plurality of rebars; and
 encasing a plurality of base assemblies of the plurality of bollard assemblies and the plurality of rebars.

26. The method of claim 25, further comprising:

15 providing a fill material in a plurality of bollard members of the plurality of bollard assemblies to increase a mass of the plurality of bollard assemblies.

27. The method of claim 26, wherein the plurality of bollard members form part of a street furniture.

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28. The method of claim 25, wherein the trench has a height of between about 0.20 m to about 1.00 m.

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