reduction of noise and vibration must be preceded. Furthermore, it is necessary to control blast vibration and noise which occupy a large part of construction pollution during tunnel excavation. Thus, a mechanical excavation method may be applied to a section adjacent to a target obstacle, in order to minimize the influence of blast vibration and noise. However, when the mechanical excavation method is applied, the working period may be excessively delayed to thereby decrease constructability and increase an economic loss. Therefore, there is an urgent demand for a substitute method.

[0005] Most of conventional methods for controlling blasting noise during tunnel blasting have been focused on a center cut blast method. For example, method for excavating a working face by multi-stage blasting method using sequential blasting machine of electric detonation and Pre-Large Hole Boring Machine(hereinafter referred to as "PLHBM") using borehole diameter 200mm over in a single-free-surface tunnel blasting operation have been proposed. According to the multi-stage blasting method using electric detonators, a delay interval for entire blasting holes of a tunnel is artificially adjusted to control vibration, as illustrated in FIGS. 1 ~~and~~ to ~~2~~4. In the multi-stage blasting method using electric detonators, it is necessary to reduce a charge weight per delay in terms of vibration

control by the sequential blasting machine. Thus, the multi-stage blasting method using electric detonators may partially overcome the limitation in adjusting delay time of electric detonators, but has low delay time accuracy for delay elements of the electric detonators and contains an electrical risk at all times. Furthermore, as non-electric detonators are actively used, the use of electric detonators has gradually decreased.

[0006] The PLHBM has been developed to control vibration of a cut portion during a tunnel blasting operation, as illustrated in FIGS. ~~2A~~3 and ~~2B~~4. According to this technique, a cut portion is not formed through a blasting operation, but an uncharged hole having a predetermined size is drilled to build an artificial two-free-surface condition. Then, the magnitude of vibration generated during a one-free-surface blasting operation may be minimized.

[0007] However, this method requires separate dedicated excavation equipment to perform a large-diameter horizontal boring operation. Furthermore, an excessive amount of time is required to carry, install, and dismantle the excavation equipment, and other operations cannot be simultaneously performed while the excavation equipment is operated. Thus, when this method is applied, the working period required for actual operation inevitably increases. In particular,

off or misfire, and has no economical feasibility.

[0021] The present applicant has proposed a blast system and method using a combination of electronic and non-electric detonators (Korean Patent Laid-Open Publication No. 10-0665880) as a measure for improving the constructability and economical feasibility of an excavation method, and spread the blast system and method to various sites.

[0022] As illustrated in FIGS. ~~3A~~ 5 and ~~3B~~6, the blast system and method is characterized in that a blast zone is divided into a cut region 100, a stopping region 120, a contour region 130, and a floor region 140, electronic detonators are arranged in the cut region 100, non-electric detonators are arranged in the stopping region 120, the floor region 140, and the contour region 130 through a leading wire, and the electronic detonators 201 and the non-electric detonators 202 are blasted with a delay time.

[0023] Reference numeral 203 represents a 0-ms electronic detonator, and reference numeral 204 represents an electronic-detonator blasting machine.

[0024] According to the above-described blast system and method, the electronic detonators capable of performing a blasting operation at a precise delay time are used in the cut region only where the confinement of rock mass is the largest, during a tunnel blasting operation. Thus, an independent waveform may be implemented for each blasting

CLAIMS:

1. A blast system using a combined pattern of electronic and non-electric detonators, comprising:

a blast excavation area divided into a cut region formed in the center of the excavation area, a stopping region formed around the cut region, a contour region formed at the outermost part of the stopping region, and a floor region formed at the bottom of the cut region;

electronic detonators arranged in the cut region and the contour region of the blast excavation area and connected through a leading wire;

non-electric detonators arranged in the stopping region and the floor region of the blast excavation area and connected through a leading wire; and

an electronic-detonator blasting machine for blasting the electronic detonators and the non-electric detonators with a delay time,

wherein the cut region comprises a horizontal cut pattern in which one or more large-diameter uncharged holes are arranged, ~~.~~

wherein a delay time of 10 to 50ms is set to each hole of the cut region.

2. A blast system using a combined pattern of

electronic and non-electric detonators, comprising:

a blast excavation area divided into a cut region formed in the center of an excavation section, a stopping region formed around the cut region, a contour region formed at the outermost part of the stopping region, and a floor region formed at the bottom of the cut region~~floor region forming the cut region~~;

electronic detonators arranged in the cut region and the contour region of the blast excavation area and connected through a leading wire;

non-electric detonators arranged in the stopping region and the floor region of the blast excavation area and connected through a leading wire; and

an electronic-detonator blasting machine for blasting the electronic detonators and the non-electric detonators with a delay time,

wherein an angle-cut pattern based on a V-cut pattern is formed in the cut region, ~~.~~

wherein a delay time of 10 to 50ms is set to each hole of the cut region.

~~3. (canceled) The blast system of claim 1 or 2, wherein a delay time of 10 to 50ms is set to each hole of the cut region.~~

~~4~~3. The blast system of claim 1 or 2, wherein a delay time of each detonator in the cut region and the contour region, in which the electronic detonators are arranged, is set in the range of 10 to 20ms for hard rock (high strength), in the range of 15 to 25ms for moderate rock (medium strength), or in the range of 25 to 35ms for soft rock (low strength).

~~5~~4. The blast system of claim 1 or 2, wherein electronic detonators are additionally arranged in a part of the stopping region, in order to expand the cut region.

~~6~~5. A blast method using a combined pattern of electronic detonators and non-electric detonators, comprising:

a first step of dividing a blast excavation area into a cut region, a stopping region, a contour region, and a floor region according to a rock mass condition of ground to be excavated;

a second step of arranging electronic detonators in the cut region and the contour region, arranging non-electric detonators in the stopping region and the floor region, and connecting the electronic detonators and the non-electric detonators through leading wires;

a third step of setting a delay time in consideration of a detonator delay time for each hole in the divided regions of the blast excavation area and an error range of the detonators;

and

a fourth step of performing detonation according to the following sequence: the cut region, the stopping region, the floor region, and the contour region, with the delay time of the third step; ~~.~~

wherein in the third step, a delay time of each detonator in the cut region and the contour region, in which the electronic detonators are arranged, is set in the range of 10 to 20ms for hard rock (high strength), in the range of 15 to 25ms for moderate rock (medium strength), or in the range of 25 to 35ms for soft rock (low strength);

wherein a delay time of ±5 to 10ms is added to the delay time of each detonator, in consideration of mucking speed of rock based on an advance; and

wherein in the blast sequence of the fourth step, the roof and the left and right wall of the contour region are divided into two or three regions in such a range that does not exceed an allowable charge weight per delay, in order to control charge weight per delay, and simultaneous delay blast is then performed for each region.

~~7~~6. The blast method of claim ~~6~~5, wherein the first step comprises forming a horizontal cut pattern in the cut region, the horizontal cut pattern having one or more large-diameter uncharged holes arranged therein.

~~8~~7. The blast method of claim ~~6~~5, wherein the first step comprises drilling the cut region according to an angle-cut pattern based on a V-cut pattern.

~~9~~8. The blast method of claim ~~6~~5, wherein the second step comprises arranging second electronic detonators in a part of the stopping region.

~~10. The blast method of claim 6, wherein in the third step, a delay time of each detonator in the cut region and the contour region, in which the electronic detonators are arranged, is set in the range of 10 to 20ms for hard rock (high strength), in the range of 15 to 25ms for moderate rock (medium strength), or in the range of 25 to 35ms for soft rock (low strength)~~

~~11. The blast method of claim 10, wherein a delay time of ±5 to 10ms is added to the delay time of each detonator, in consideration of mucking speed of rock based on an advance.~~

~~12~~9. The blast method of claim ~~6~~5, wherein the third step comprises determining a delay time through analysis of waveforms obtained by performing a small-scale test blast for a section which is extremely sensitive to occurrence of

vibration.

~~13. The blast method of claim 6, wherein in the blast sequence of the fourth step, the roof and the left and right wall of the contour region are divided into two or three regions in such a range that does not exceed an allowable charge weight per delay, in order to control charge weight per delay, and simultaneous delay blast is then performed for each region.~~

~~14~~10. The blast method of claim ~~6~~5, wherein in the blast sequence of the fourth step, an initial delay time of the stopping region in which the non-electric detonators are arranged is reflected by adding a delay time of 200 to 500ms to a final delay time of the cut region.

~~15~~11. The blast method of claim ~~6~~5, wherein in the blast sequence of the fourth step, a constant delay time of about 10ms is sequentially applied to contour hole lines of the contour region in consideration of an allowable vibration level, and delay blast is alternately performed in the left and right sides by turns.

~~16~~12. The blast method of claim ~~6~~5, wherein in the blast sequence of the fourth step, when the contour region having

electronic detonators arranged therein is started, a delay time of 300 to 1,000ms is set in consideration of a delay time of a non-electric detonator which is finally detonated in the floor region and an allowable error of the non-electric detonator.

~~17~~13. A blast method using a combined pattern of electronic detonators and non-electric detonators, comprising:

a first step of dividing an excavation area of open pit adjacent to an urban area or obstacle into a primary stopping region, a secondary stopping region, and an excavation line region;

a second step of arranging electronic detonators in the primary stopping region and the excavation line region, arranging non-electric detonators in the secondary stopping region, and connecting the electronic detonators and the non-electric detonators through leading wires;

a third step of setting a delay time of 10 to 50ms for each detonator in the divided regions of the excavation area of open pit and setting a surface delay time of 100 to 500ms, in order to induce each definite independent waveform through delay blast of each hole formed in the excavation area of open pit; and

a fourth step of performing detonation according to the following sequence: the primary stopping region, the secondary

stopping region, and the excavation line region, with the delay time of the third step.