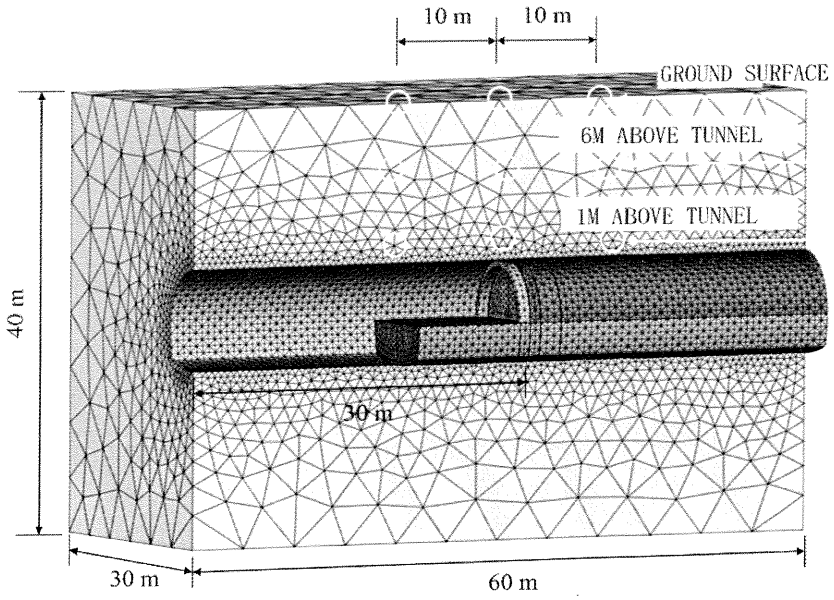
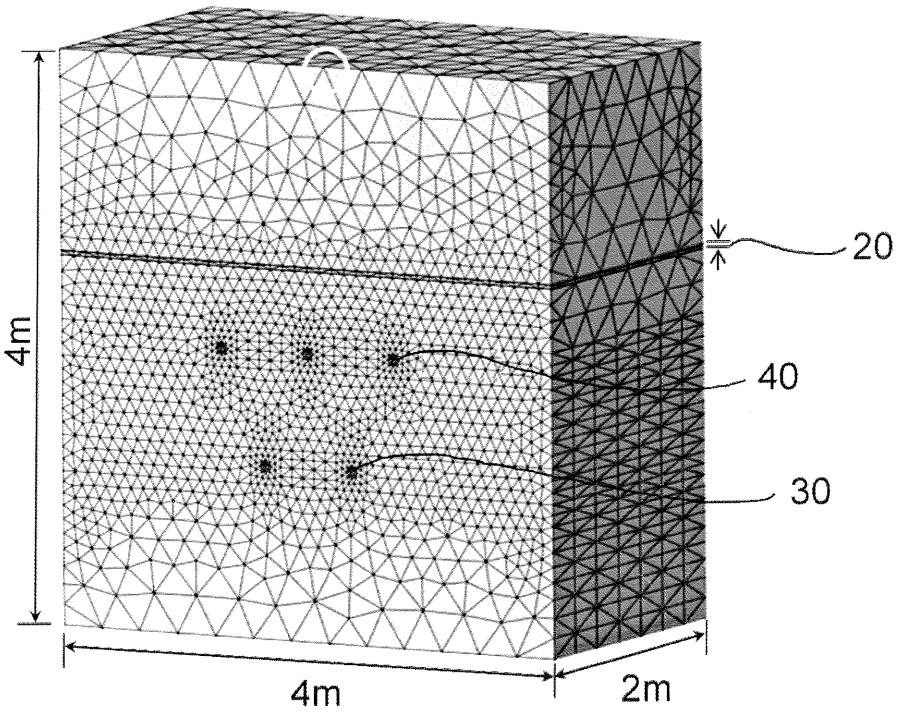
[FIG 13]

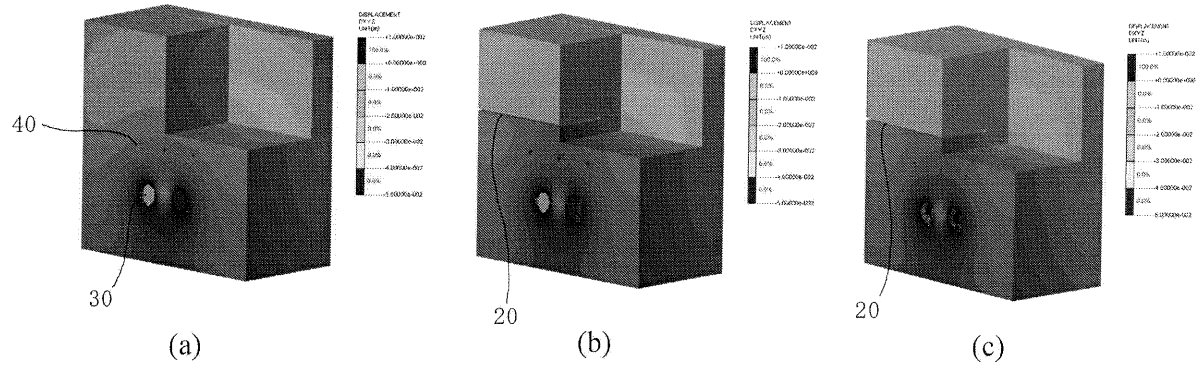

10 m
10 m
GROUND SURFACE
6M ABOVE TUNNEL
1M ABOVE TUNNEL
40 m
30 m
30 m
60 m

(a)


4m
20
40
30
4m
2m

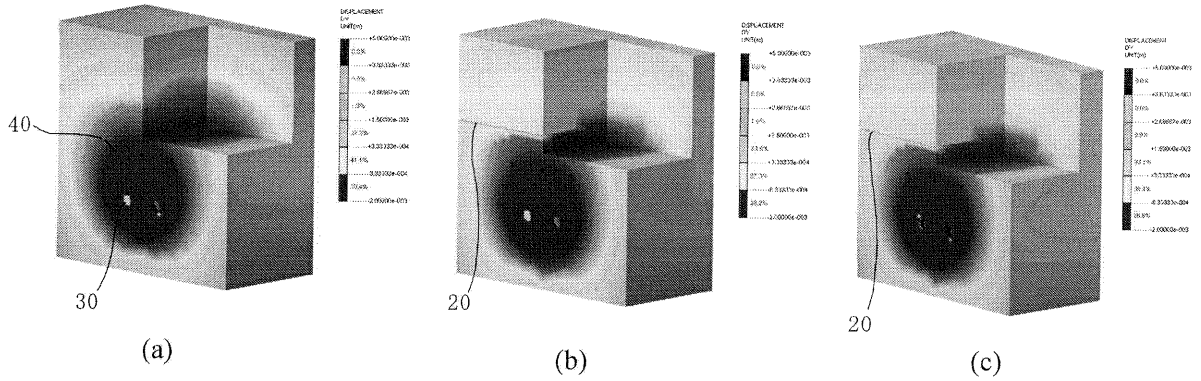
(b)

[FIG 15]



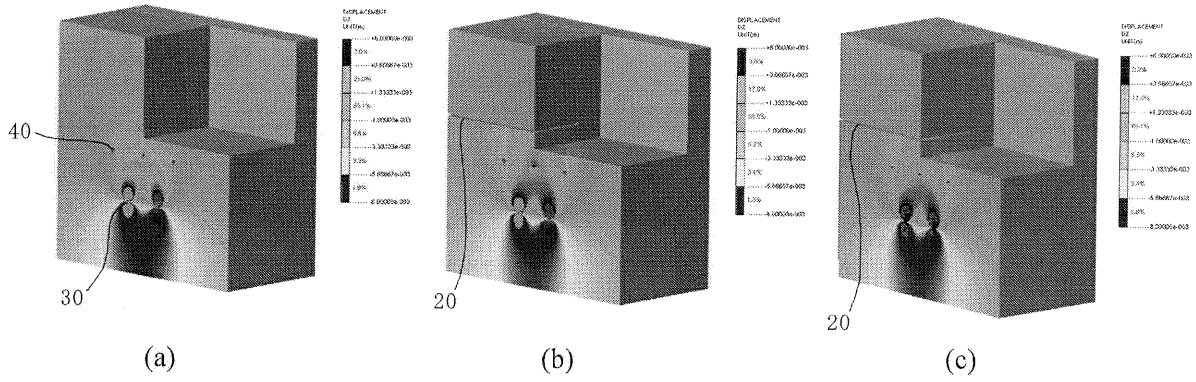
(a) (b) (c)

[FIG 16]



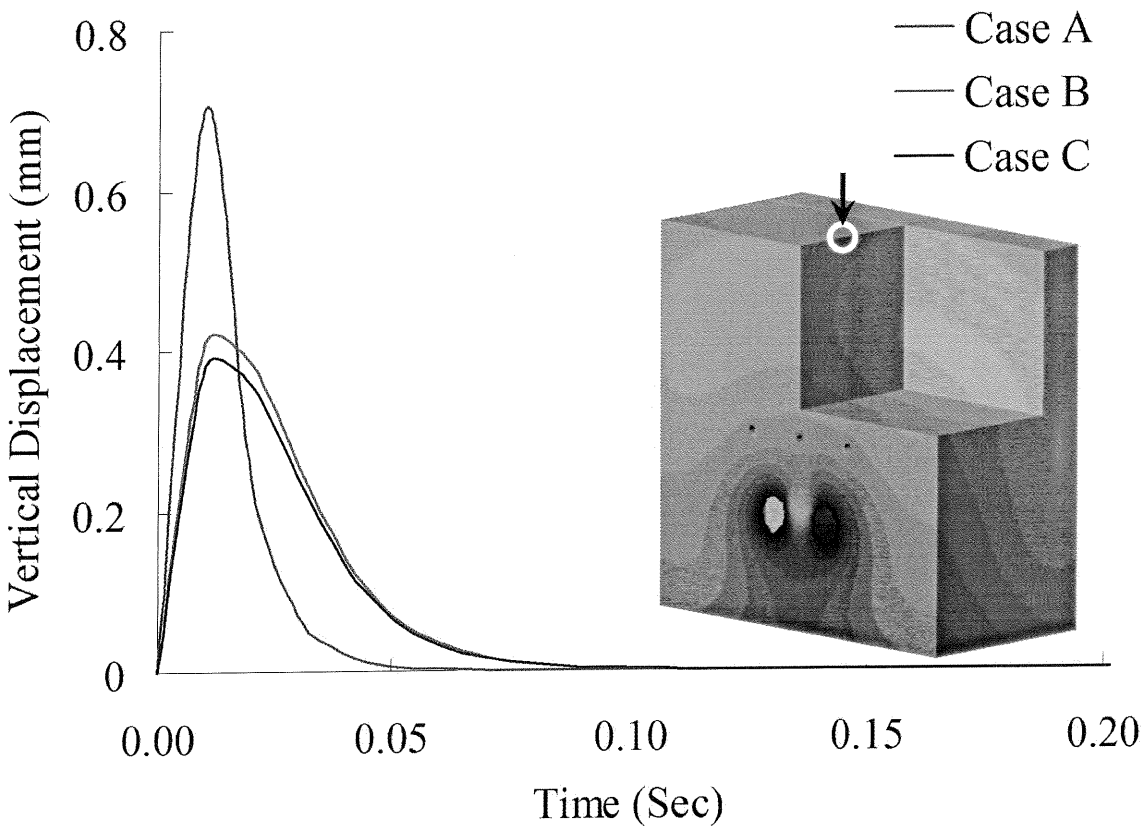
(a) (b) (c)

[FIG 17]

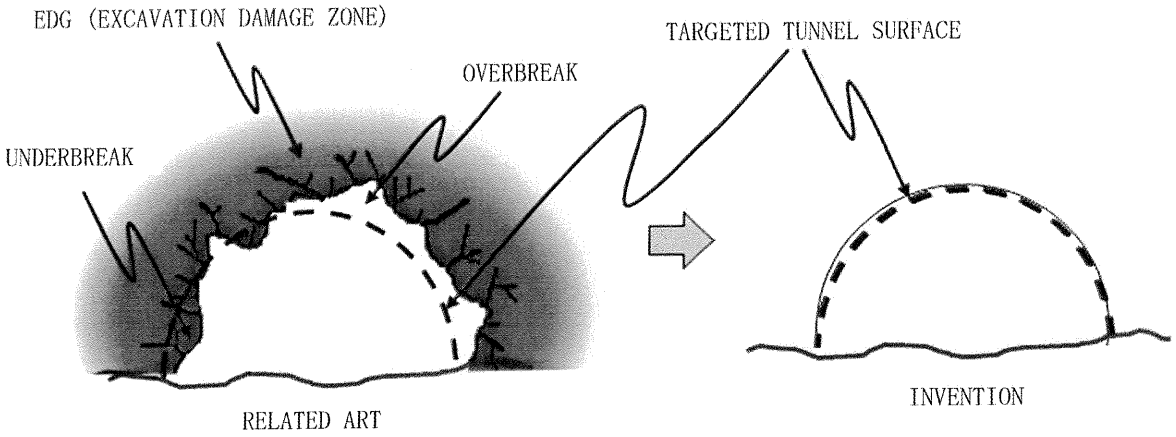


(a) (b) (c)

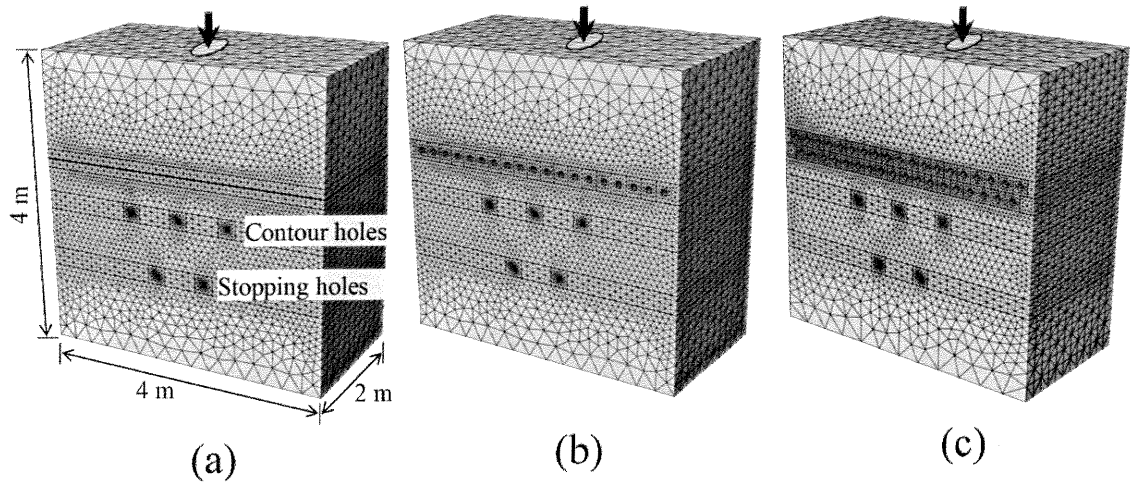
[FIG 18]

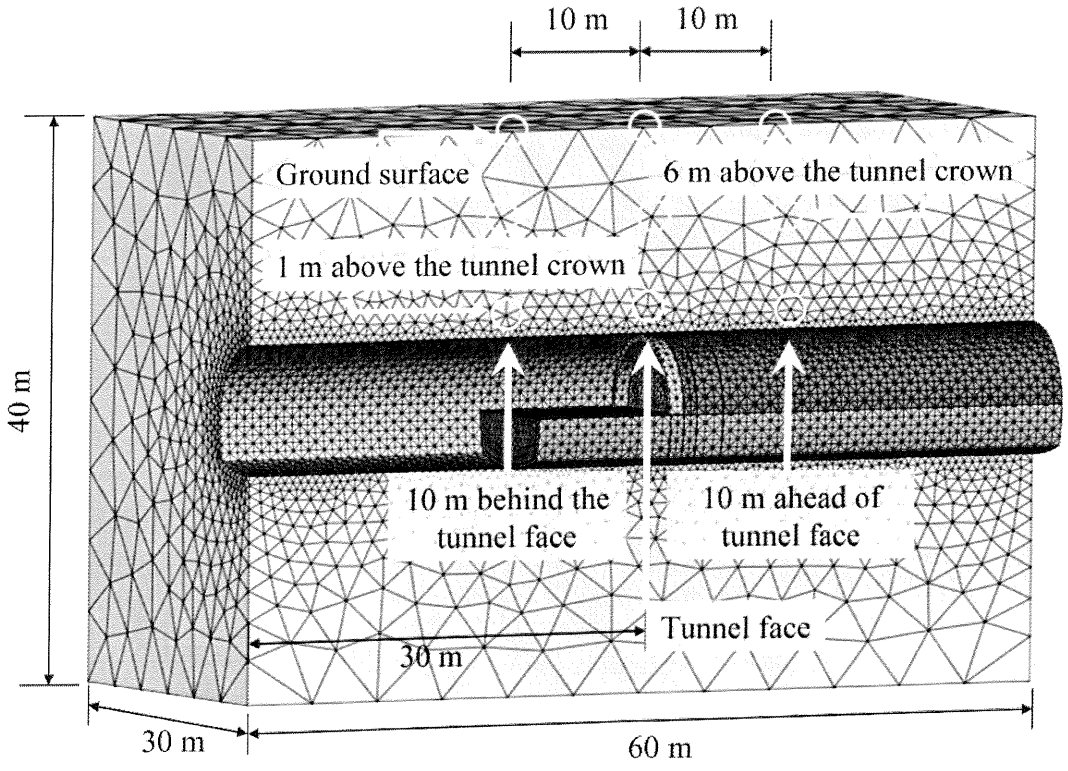

Case A
Case B
Case C
Vertical Displacement (mm)
0.8
0.6
0.4
0.2
0
0.00
0.05
0.10
0.15
0.20
Time (Sec)

[FIG 21]

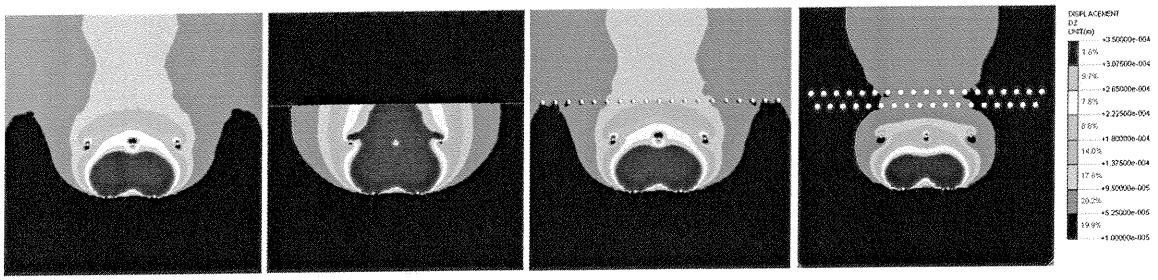

EDG (EXCAVATION DAMAGE ZONE)
OVERBREAK
UNDERBREAK
TARGETED TUNNEL SURFACE
RELATED ART
INVENTION

[FIG 22]


4 m
Contour holes
Stopping holes
4 m
2 m
(a)
(b)
(c)


10 m
10 m
Ground surface
6 m above the tunnel crown
1 m above the tunnel crown
40 m
10 m behind the tunnel face
10 m ahead of tunnel face
Tunnel face
30 m
30 m
60 m

[FIG 23]



TYPICAL TUNNEL (a) (b) (c)

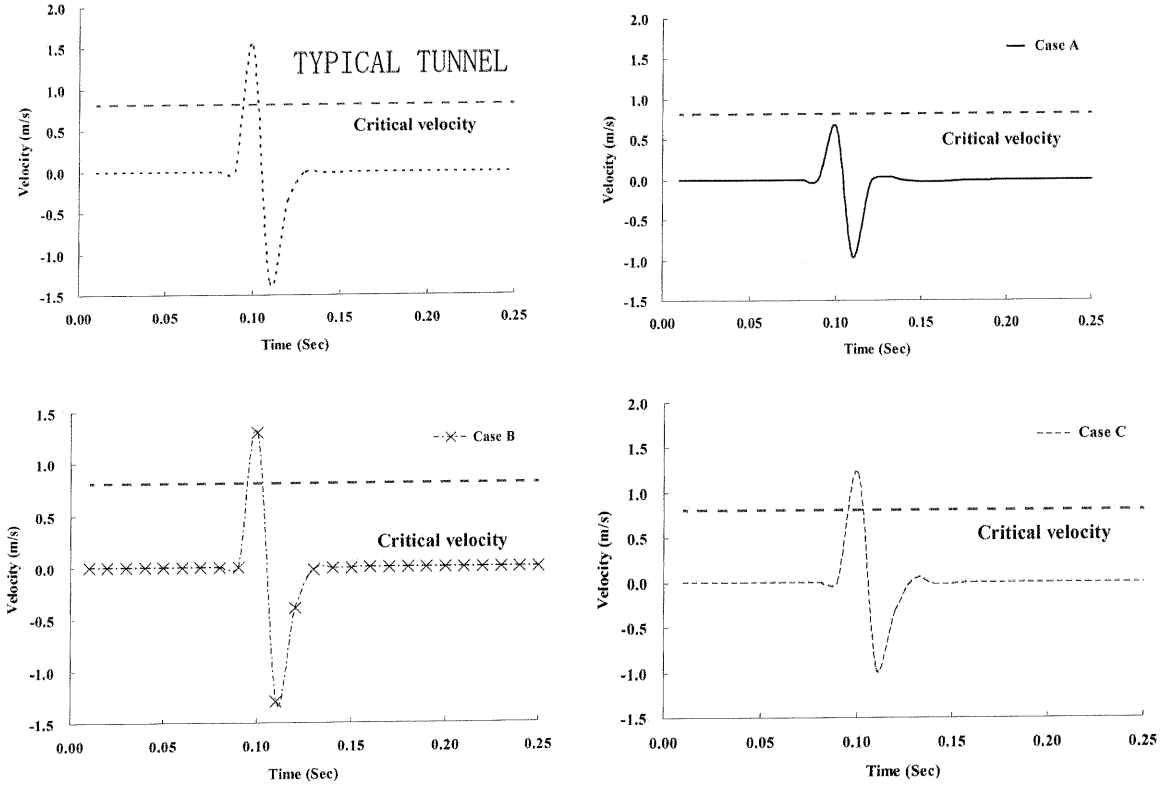
MAXIMUM VERTICAL DISPLACEMENT CONTOUR



TYPICAL TUNNEL (a) (b) (c)

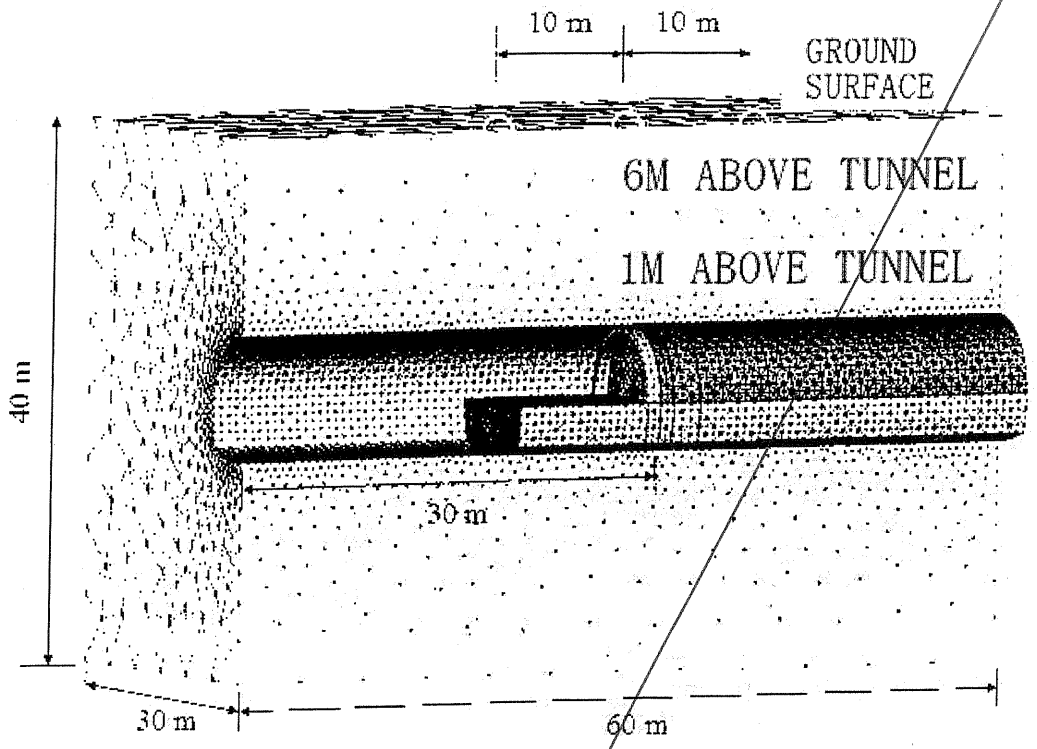
PEAK PARTICLE VELOCITY IN THE VERTICAL DIRECTION

[FIG 24]

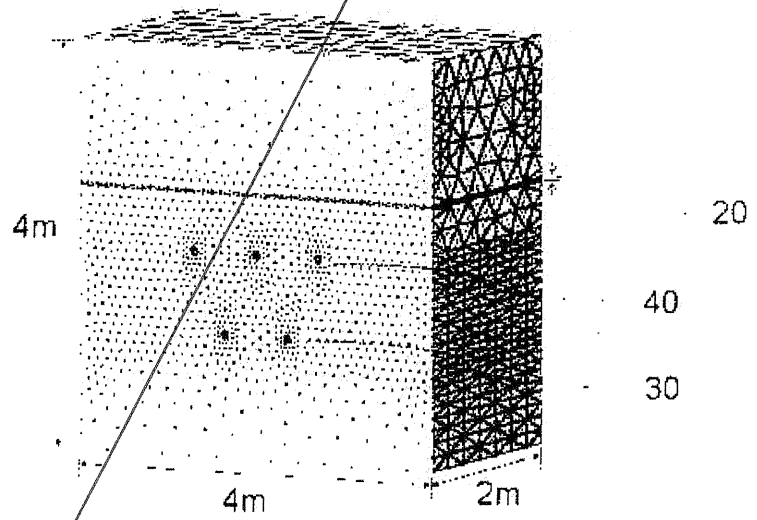


HISTORY OF VERTICAL PARTICLE VELOCITIES MEASURED AT 2 M ABOVE THE CONTOUR HOLE

[FIG 13]

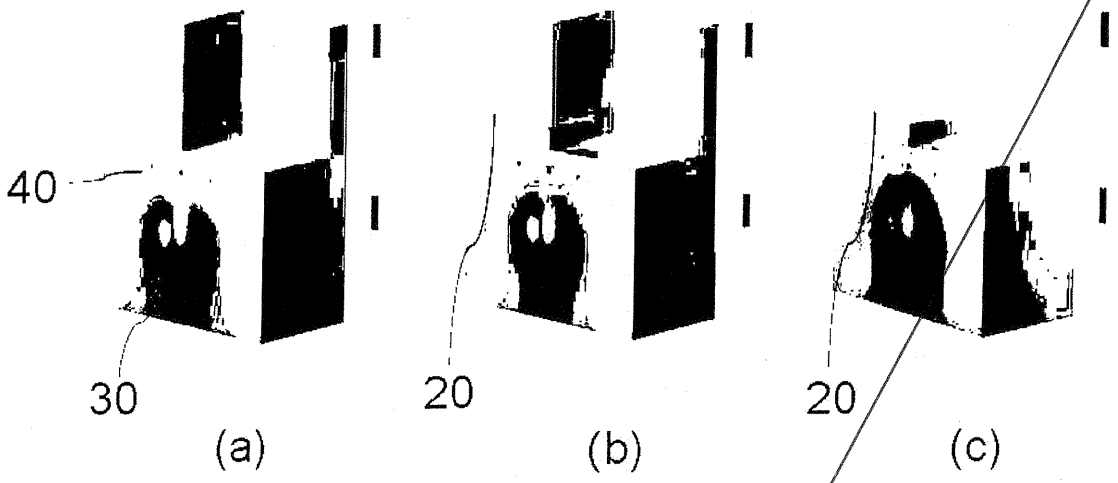

10 m
10 m
GROUND SURFACE
6M ABOVE TUNNEL
1M ABOVE TUNNEL
40 m
30 m
30 m
60 m

(a)

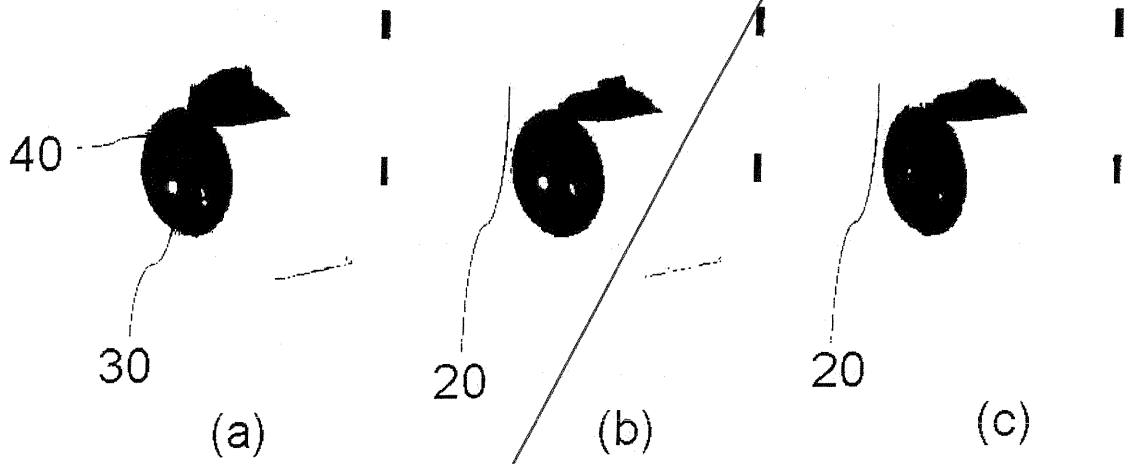

4m
20
40
30
4m
2m

(b)

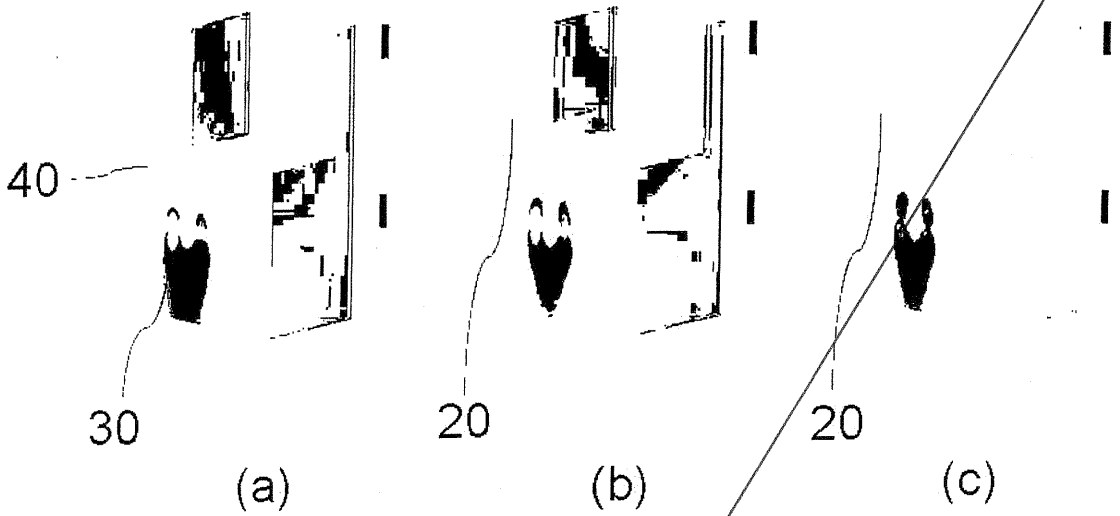
[FIG 15]



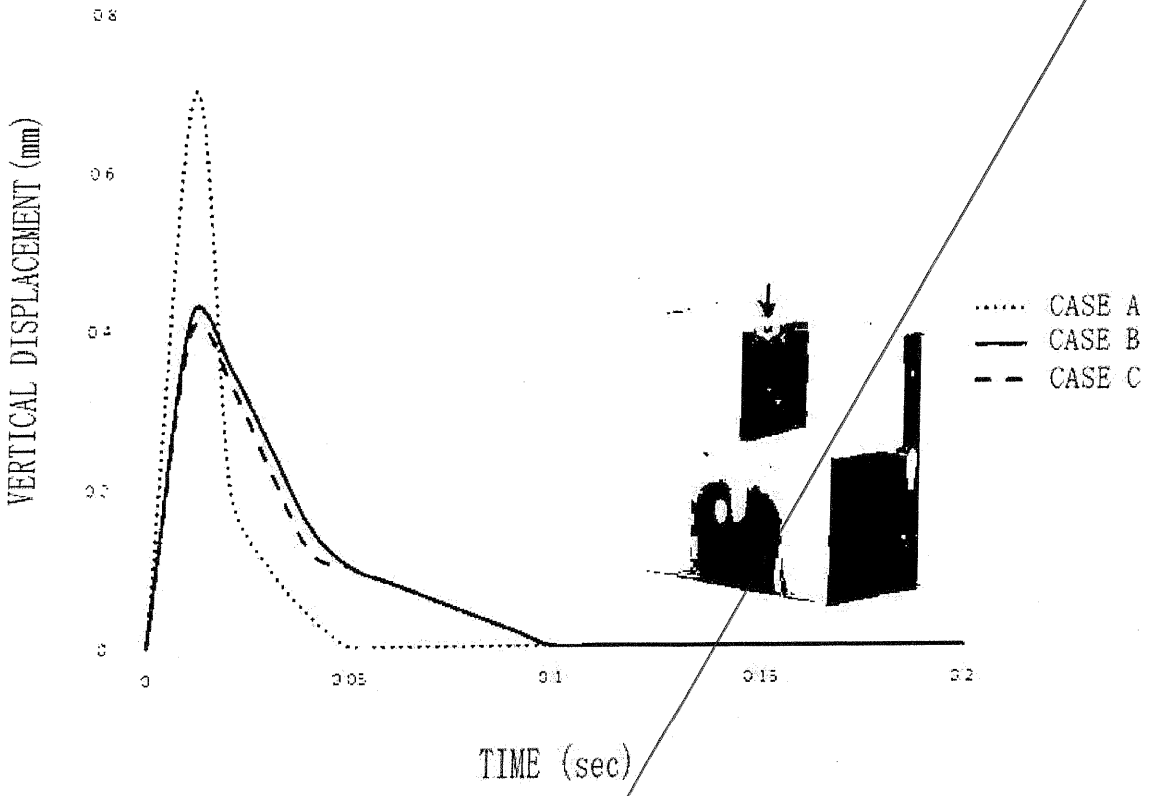
[FIG 16]



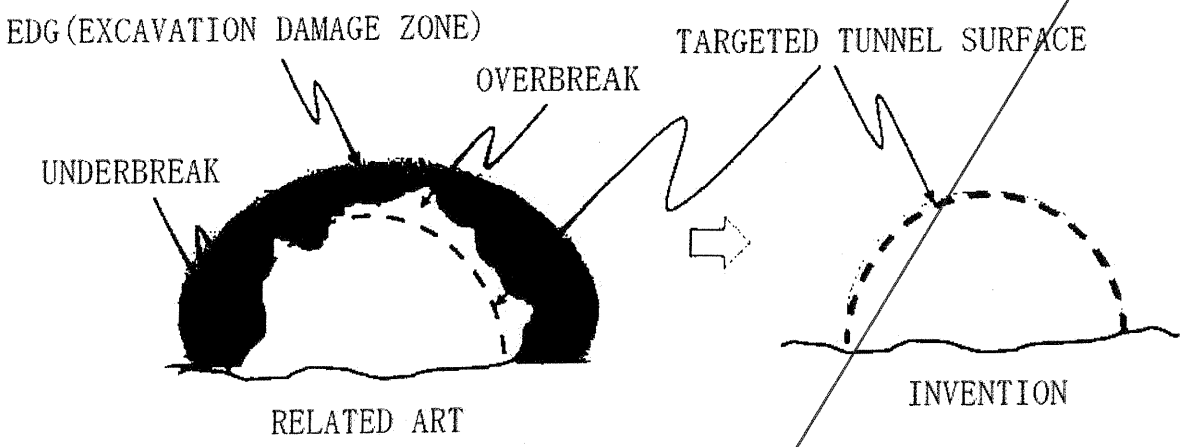
[FIG 17]



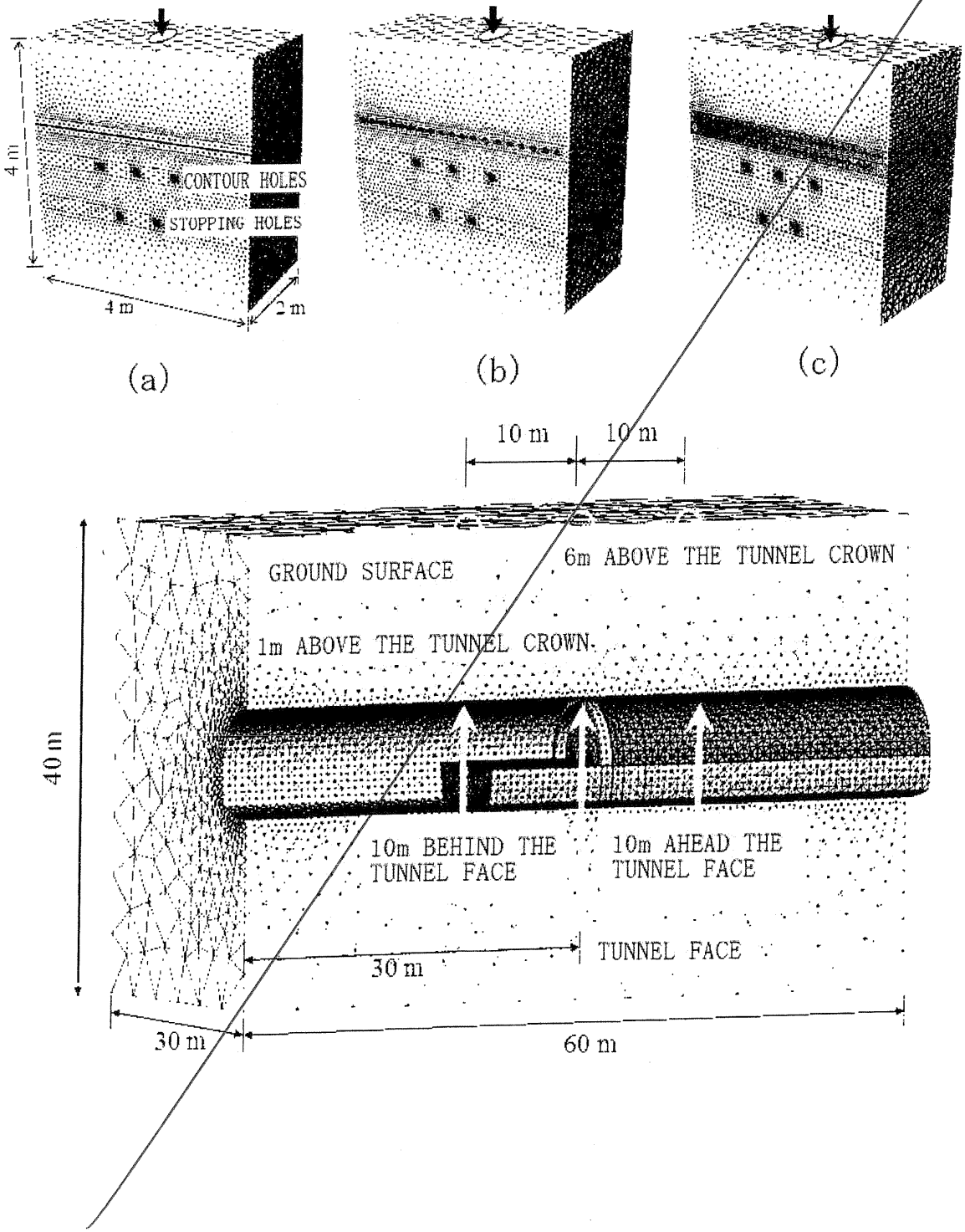
[FIG 18]


VERTICAL DISPLACEMENT (mm)
0.8
0.6
0.4
0.2
0
0
0.05
0.1
0.15
0.2
TIME (sec)
CASE A
CASE B
CASE C

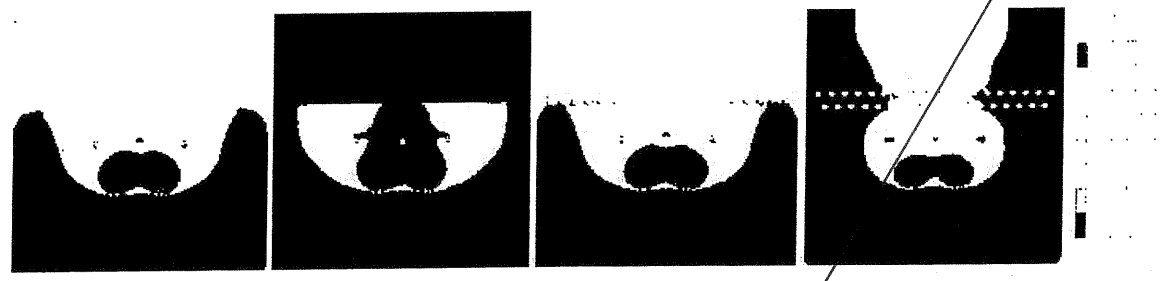
[FIG 21]


EDG(EXCAVATION DAMAGE ZONE)
OVERBREAK
UNDERBREAK
TARGETED TUNNEL SURFACE
RELATED ART
INVENTION

[FIG 22]

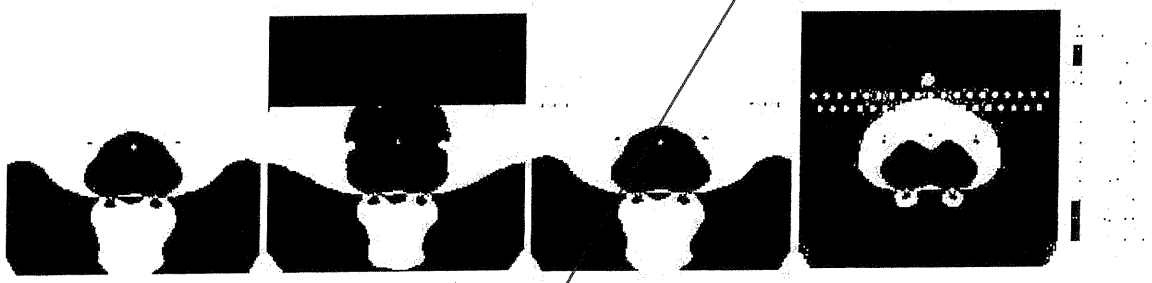

4 m
CONTOUR HOLES
STOPPING HOLES
4 m
2 m
(a)
(b)
(c)
10 m
10 m
GROUND SURFACE
6m ABOVE THE TUNNEL CROWN
1m ABOVE THE TUNNEL CROWN
40 m
10m BEHIND THE TUNNEL FACE
10m AHEAD THE TUNNEL FACE
30 m
TUNNEL FACE
30 m
60 m

[FIG 23]



TYPICAL TUNNEL (a) (b) (c)

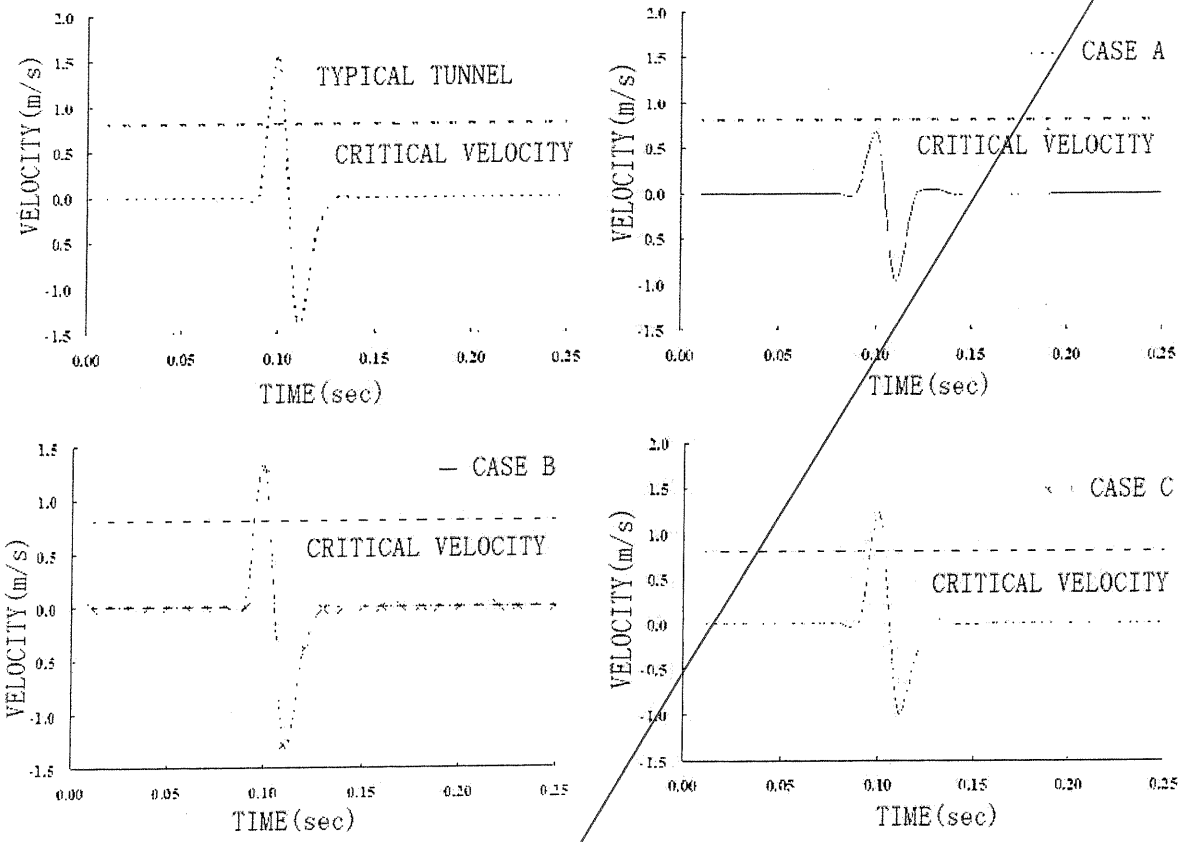
MAXIMUM VERTICAL DISPLACEMENT CONTOUR



TYPICAL TUNNEL (a) (b) (c)

PEAK PARTICLE VELOCITY IN THE VERTICAL DIRECTION

[FIG 24]



HISTORY OF VERTICAL PARTICLE VELOCITIES MEASURED AT 2 M ABOVE THE CONTOUR HOLE