[論 文]

On The Development of Blasting Technology in Korea

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[註]
本論文은 SAME (Society of American Military Engineers) 主催 年例 學術大會인 '96 'Peninsula Engineer Conferenee 가 2月 16日－17日間 美八軍 South post, Dragon－hill lodge 에서 Building과 Combat Enginrring로 나누어서 100여명 參席으로 盛旺을 이루었다. 特히 우리 技術士會에서는 許塡博士 (SAME Seoul post－Vice－President) 우리 技術士會 副會長과 全相伯 技術士(弘報委員長)두분이 發表한 全文이다.

Contents

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1. Progress of Explosives

1－1 Consumption pattern of Explosives

The Consinption of Explosives is required by need.
In 1950′s The Stragic Ore such as Tungsten, Iron Ore, and Coal production were the most prosperous during Korea War. The Coal production was Continued from in 1960′s to begins of 1980, unedr strong Government AID. The Consumption of Explosives Occupied 80% of it in the field of Coal mining. but, by Export Drive policy, The GNP would raise us 3,000$, Them Goverment set up the policy "Oill is main, Coal is sub." Since middle of 1980′s.
The Constuction was Boomed Through Vietnam War and middle East Area. So. 70% of Explosives was Consumed in The field of Construction Industry.
Now, We look Out the Development of Explosives, In 1950′s Hanwha maker produced Dynamite, Ammonuim Nitrate, Black powder, TNT and Electric Caps.
In 1980′s produced ANFO and The Begins of 1980′s produced Slurry and Emulsion under Du′ponts Technical Inducement. Them, Seoul Subway Construction work started again #2#3#4 line simultaneously and also M/S Electric Caps, Hinel Caps came out.
Now a day, We used Sequential Blasting Machine.
Since Koryo Explosives Co, in Pusan produced same kind of Emulsion under Nitro Novel′s Assistance In present we faced two maker′s in Korea.

〈Explosives Consumption Statistics〉

1) Use

Kinds \ Year	1991	1992	1993	1994
Coal	4,900	4,000	3,600	3,400
Limestone	10,000	11,000	12,000	12,000
Metal Ore	4,000	5,500	3,500	3,000
Construction	28,000	32,000	35,000	32,000
Total	46,900	52,500	52,100	50,900

2) Powder

Kinds \ Year	Dynamite	Emulsion	Amm,Nitrate	ANFO	Finex	Total
1991	30,800	3,750	2,100	10,000	250	46,000
1992	35,000	4,330	1,900	11,000	270	52,000
1993	33,000	5,020	1,800	12,000	280	51,100
1994	32,000	4,800	1,800	12,000	300	50,900

1–2. Explosives manufacturing

'35th Dynamite factory installed at Hung Nam, North Korea.
'50th ANFO patent by Lee & Akre in U.S.A.
'56th Dr. M. a Cook & H.E Farman slurry patent.
'61th Hanwha maker prodiced Dynamite, An, Block powder & D/S Electric Cap.
'62th Shida Mura utillzation Test ANFO in Japan.
'64th Dr. G. Huh utillzation Test ANFO in Korea under Sponsering MOC.
'67th Dr. G. Huh untillzation Test AL–ANFO in korea.
'68th Hanwha started production ANFO.
'75th Slurry Started produced under sponcering Dupont & Ireco in Japan.
'77th Dr. G. Huh utillzation Test slurry under sponcering the Construction, the Cement Association.
'81th Hanwha prodeced Emulsion, Finnex, M/S delay cap under sponsering DU'pont.
'93th Hanwha proceed Hindl (Non–electric cap)
'93th Koryo Explosives co, produed slurry & Nonel.

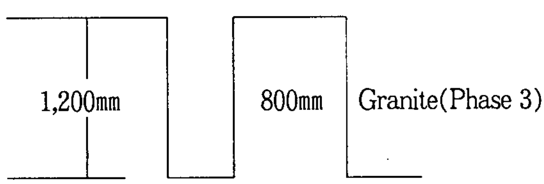
2. Development of Blasting Technology

2–1. Standard blasting pattern and Blasting Empirical Formula

The Blasting Technique is on the basis of three dimensions. The first of all, modernization of Drill machine. 2nd, Adapable Explosives (De–vibration and Les Sound) 3rd, Excellent drilling and Ignition pattern. In 1950, Korea–America Tungsten Treaty is not only Earnning is dollar but also it was Tuunning point of development of Tunnel Blasting Tcchniqne such as a Burn Cut in Tunnel. Because 6 specialsts advised us at Sang dong Tungsten Mine under Treaty. Experimental Blasting pattern for single free face (Tunnel Face) was Carried Out, As a result.

Empirical test

In case of tunnel blasting, ther is only one free–face the tunnel heading. After the center holes were blasted, the works which remain is the implementation of bench cut against the opening to make the full sectional area required. The quantity of explosives to be charged, however, is hardly extimated, as rocks very seldom show any sign of homogeneous quality.



Experimental test of bench cut

Experimental tests therfore have been implemented to calculate the specific charge of the explosives of certain strength, the spacing of holes and the diameter of holes to be drilled, as shown in the following figure.

As shown in the figure above, a series of holes are drilled at 800㎜ behind behind the face to a depth of 1,200㎜ and firings are implemented at each holes with varied charge of explosives untill the burden is teared off. Should it be realized, the specific charge of the rock to be blasted can be calculated by the following formula:

$Ca = \frac{A}{SW}$ where as A = m activated area

S = Periphral length of Charged room

Ca = Rock Coefficient

Di = Holes diameter

Later in 1980, The Dynamite Explosive was Replaced into Emulsion & Milli-Second Delay Electric Cap.

Sequential Blasting machine wer Applied to the Site.

The Subway Tunnelling have been worked so Carefully for Vibration and Noise to near Shopping and housing area. We carried out Empirical fomula to solve City Envoirement pollution as follows.

For Granite : $V = KW^{0.57} D^{-1.75}$

For Gneiss : $V = KW^{0.5} D^{-1.5}$

V = PPV (cm/sec)

K = Coefficeney

D = Distance (m)

W = Amount of powder / delay (kg)

2.2 Brief History of Blasting Techique

March, '54 Center Cut (Cut) Improved into Burn Cut in Tunnel (Face 2×2m) utillzation.

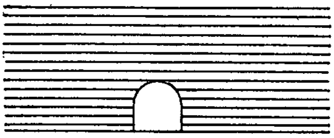
Del, '72 Dynamical study on Blasting with One-Free-Face to Utilize ANFO Explosives.

Jan '81 Center Cut Improved into Burn Cut in Tunnel (Face 7×7m) at Seoul Tunnel Construction.

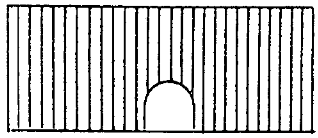
〈표 4〉 Effects of the bedding state of geological strata on blasting

A strike vertical to Tunnel axis				B Para strike Toward Tunnel axis		No. relation with strike
Dipping Direction		Reverse Dipping Direction				
Dip	Dip	Dip	Dip	Dip	Dip	Dip
45°~90°	20°~45°	45°~90°	20°~45°	45°~90°	20°~45°	0°~20°
Most Adaptable	Adaptable	Common	None-adaptable	very poor	Common	None-Adaptable

A



B



Empirical formula

Eor Granite : $V = KW^{0.57}D^{-1.75}$

For Gneiss : $V = KW^{0.5}\ D^{-1.5}$

For Concrete breaker : $V = KW^{0.}\ D^{-1.755} = 7\times 0.66^{0.5}D^{-1.75}$

W = Amount of powder / delay kg

D = distance m.

V = Partical Vibration Velocity cm / *sec*

K = Coefficency = $E_i(R_i, S_c + Q_i)$

S_c : Compressive St. kg / ㎠

E_i : Powder Conpecsation Ratio Dynamite = 1

Slurry = 0.8

AN = 0.65

R : Rock Coefficency

Seoul Granite = 0.0371

Seoul Gneiss = 0.0206

Q_i : Compensation by blasting pattern

2-3. NATM & Scale distane 發破實驗式

當學會 發破實驗式

種 別	D	D	D	Seoul 地下鐵公社 實驗式	
條 件	$V = 41(\cdots)^{-1.41}$ $W^{1/3}$	$V=124(\cdots)^{-1.66}$ $W^{1/3}$	$V=100(\cdots)^{-1.66}$ $W^{1/3}$	$V=KW^{0.57}D^{-1.75}$ (Granite)	$V=KW^{0.5}D^{-1.5}$ (Gneiss)
爆원-構造物 間 距離	-100m	+100m	+100~300m	-30m~ ~-40m	
Bit Gage	φ60~70㎜	φ60~70㎜	φ60~79㎜	φ36~ 38㎜	
使用火藥類	Kovex, M/S 電氣雷管	Kovex, M/S 電氣雷管	Kovex, M/S 電氣雷管	Kovex, M/S 電氣 雷管	
穿孔方式	Bench Cut	Bench Cut	Bench Cut	Bench Cut, Tunnel	
備值 : Bench Cut 實驗式 (片麻岩-普通岩 條件)					
但, V=振動值(Cm/Sec), K = 遲發當 裝藥量(kg) , D = 爆源 距離 (m)					

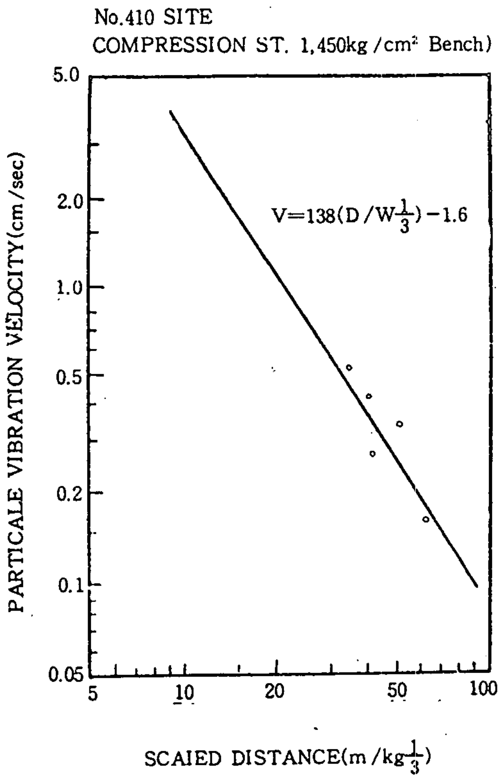


Diagram 2; Particle vibration velocity

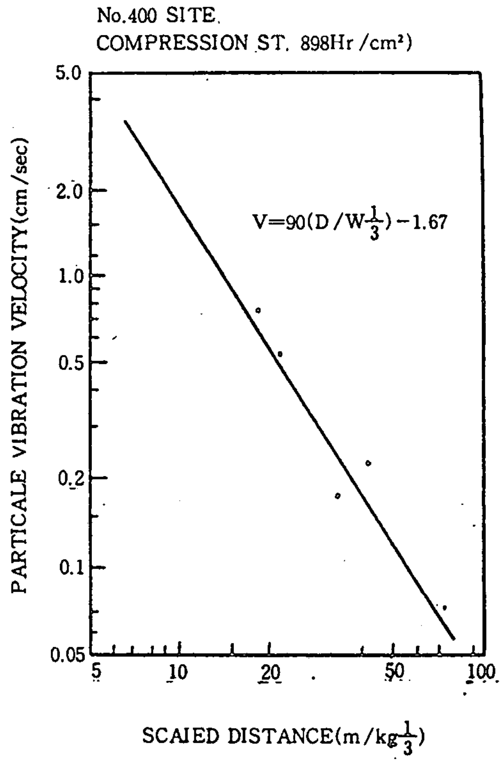


Diagram 3; Particle vibration velocity

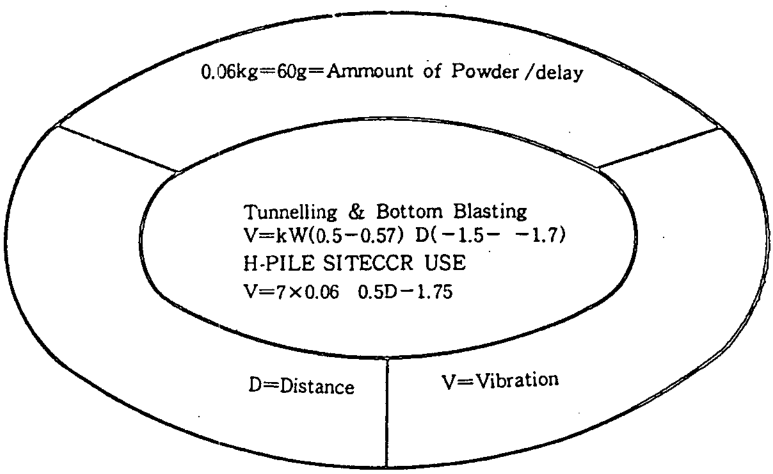


Diagram 4; Relation between vibration, powder & distance

〈표 3〉 Standardization in tunnelling

Rock Kind	I	II	III	IV	V
Rock Kind	Stable rock	moderately jointed and hard stratified or schisrose rock	fractured and friable rock	untable plastic & squeezing rock	highly plastic squeezing & swelling ground
Burden(cm) Bit Gage=38㎜	56	65	70	80	–
Drilling	full face	top heading & bench	top heading & bench	line–drilling (pilot drift & bench)	forepiling (〃)
Support	occasionally rockbolt	S.C., W.M. systematic R.B. for Cap	S.C., W.M.R.B. for cap & wall	S.C., W.M. R.B.for & steel rib	S.C., W.M.F.P, Steel lagging $ S.C. invert

*S.C. = shoterete   R.B = rock   W.M. = Wire Mesh Ca = Ror Pilling

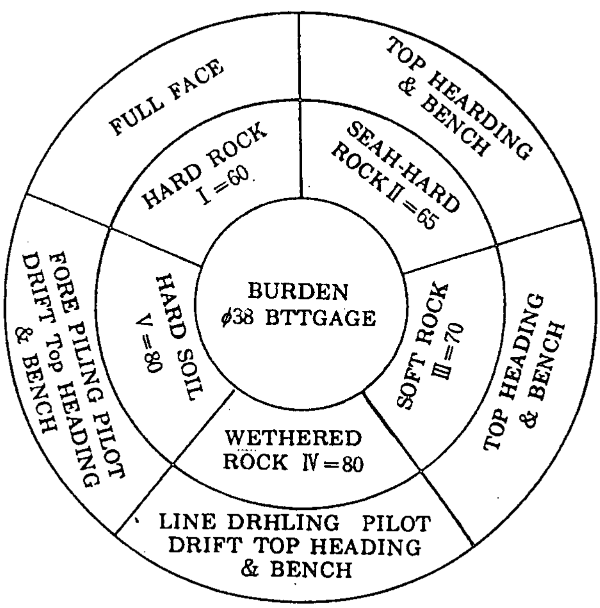


Diagram 1 ; Standardization of tunnelling

TRIGGERED Vert. at 14:38:04

04 J 1995

	TRAN	VERT	LONG
PPV	1.14	2.79	2.92 ㎜/s
FREQ	N/A	64	6 4 Hz
TIME	441	3	3 0 m s
ACCEL	0.08	0.12	0.12 g
PK DISP :	0.002	0.007	0.007㎜

PVS 3.32 ㎜/s at 31 ms

PK AIR O / P 33.5 pa.(L) at 256 mx

REQ 30 Hz

⟨SENSORCHECK (tm) CALIBRARION⟩

FT = 75 OT = 40 FV = 80 OV = 32 FL = 77 OL = 38

FM = 20 PM = 531 BL = 61

Geo sensors passed Mic test ok

Calibrated 12 Aug. 1994

by INSTANTEL INC.

⟨INSTANTEL DS477 BLASTMATE⟩

SERIAL # 206 V5.3

CLIENT 9inn huh

LOCATION

USER

TRIG SOURCE geo or mic

TRIG LEVEL 1.00㎜ / s 250.0 pa.(L)

RECORD TIME 7s

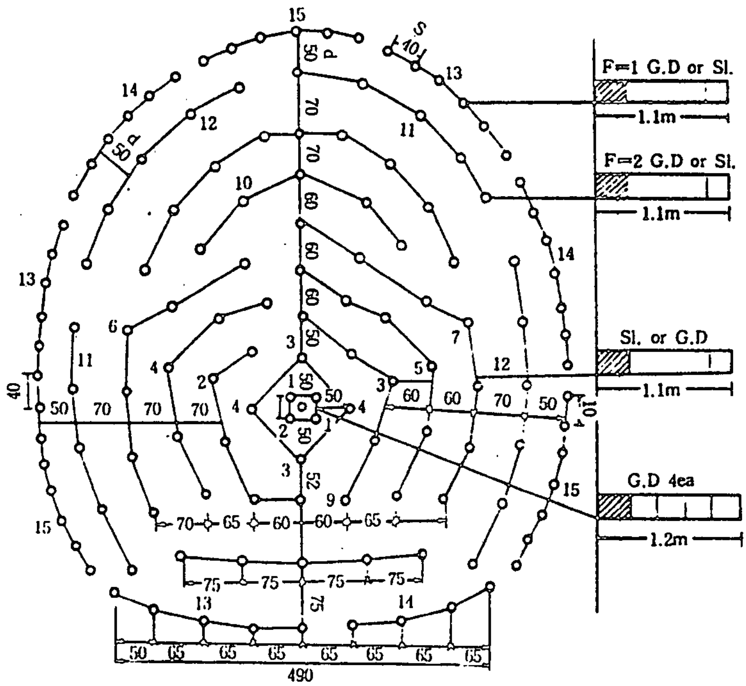
NOTES:

TRIGGERED Vert. at 15:26:20

04 July 1995

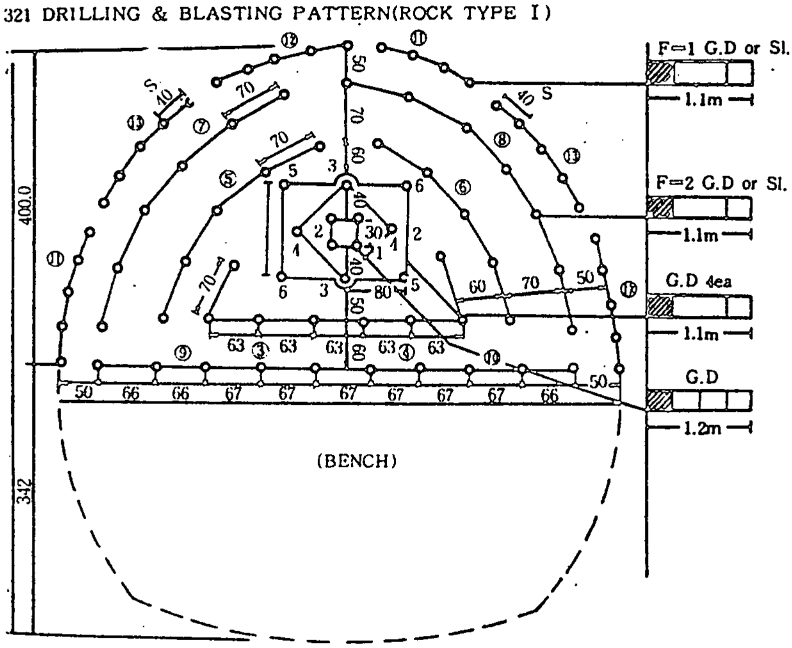
	TRAN	VERT	LONG
PPV	1.40	3.43	3.94 ㎜/s
FREQ	N/A	64	57 Hz
TIME	36	119	31 m s

NO. 321 DRILLING & BLASTING PATTERN(ROCK TYPE I)

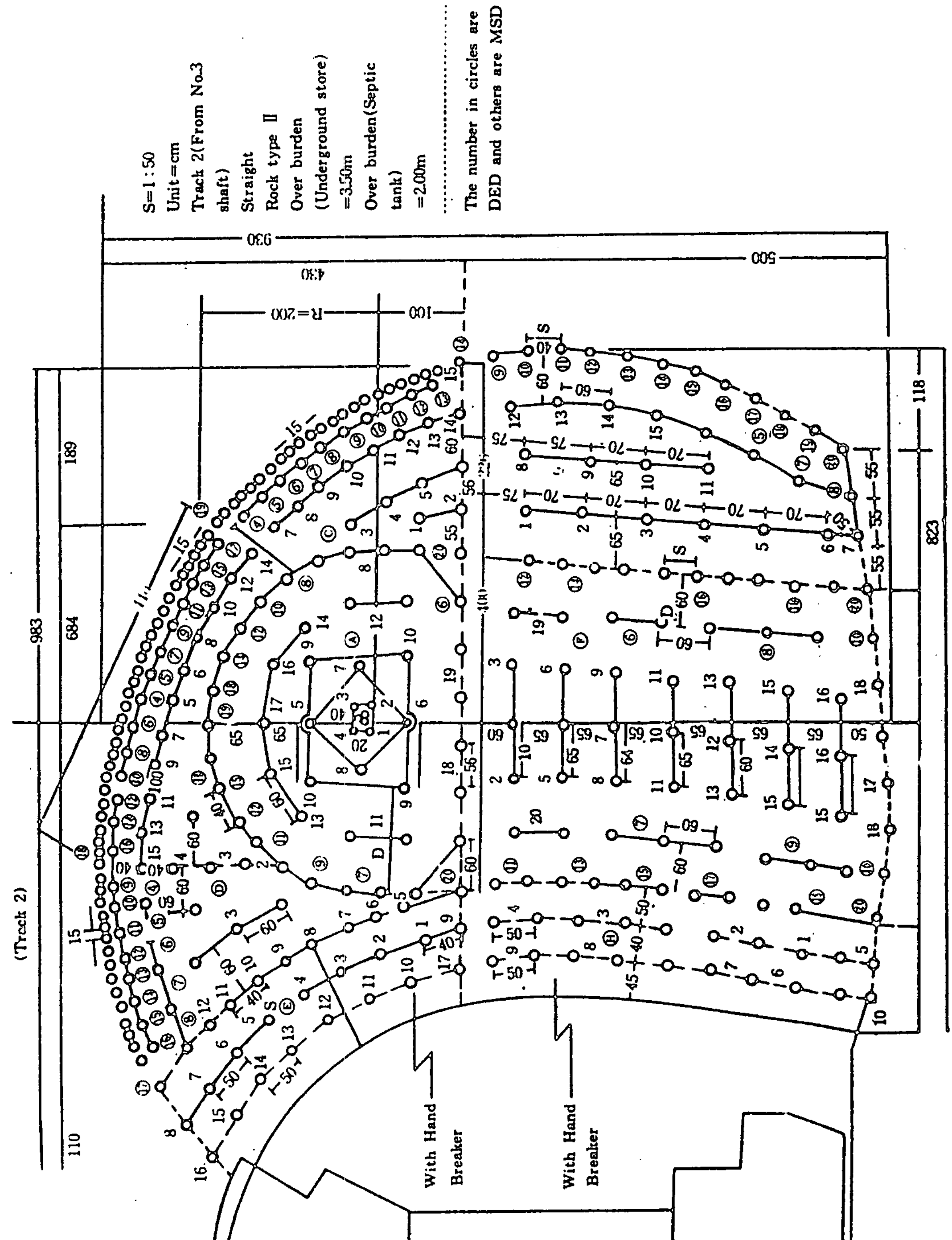


〈그림 18〉 Drilling & blasting pattern(rock type 1)

NO. 321 DRILLING & BLASTING PATTERN(ROCK TYPE I)



〈그림 19〉 Drilling & blasting pattern(rock type 1)


S=1:50
Unit=cm
Track 2(From No.3
shaft)
Straight
Rock type II
Over burden
(Underground store)
=3.50m
Over burden(Septic
tank)
=2.00m
The number in circles are
DED and others are MSD
(Track 2)
With Hand
Breaker
With Hand
Breaker

〈그림 20〉

3. Conclusion

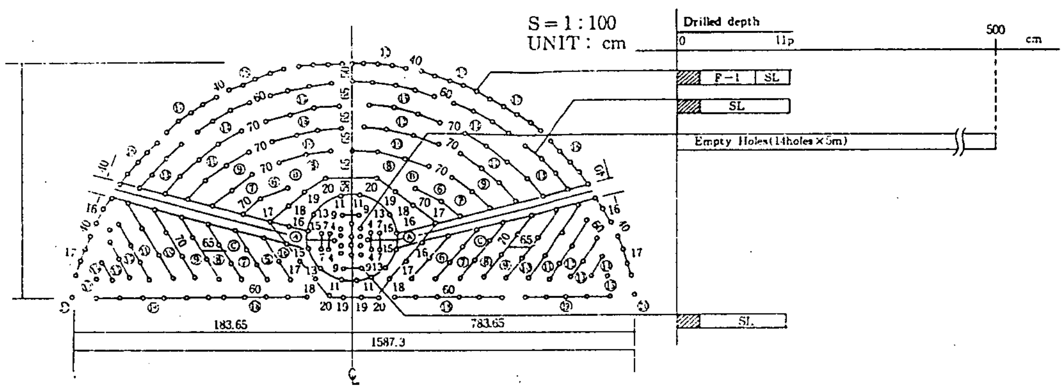
In The explosives Controll Engineers, There are several Classifications, from Engineer (1st class, 2nd class) to professional Engineer. These Engineer are mainly worked for the production such as quarries Rock & Limestone, Subway. Road & High speed R-R Tunnel ane Out Crop Toad and also rarely DAM, Oil storage.

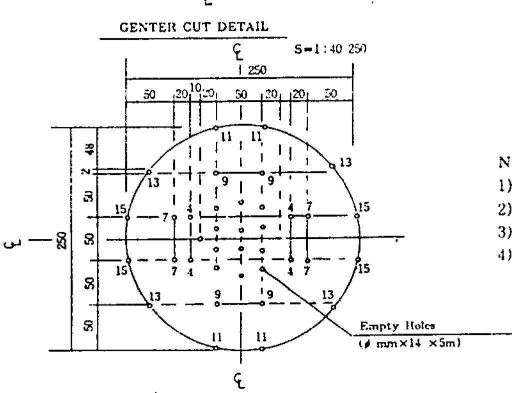
Progessional Engineer are maily Design and Inspection bisines above job site and also Technical Diagonis.

Now a day, We are proud so efficency Work with Sequential Blasting machine at Subway Tunnel Works but I expect to apply Mac's auto marking System at Tunnel face sooner and hop to meet Robot Drill Machine Presentation in the Near Future.

서울지하철 7-20공구 방배연립주택 TUNNEL (多段發破器 適用)

DRILLING & IGNITION PATTERN (STA 30k 390)





NOTE :
1) 뇌관번호를 절대엄수해야 한다.
2) ○ : DSD others MSD
3) Burden : 65cm, Spacing : 70cm
4) 도면은 확대복사하여 사용할 것