CAUTIOUS BLASTING IN CRITICAL AREAS AT RAMAGUNDAM SUPER THERMAL POWER STATION

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ABSTRACT: Addition of a 500 MW unit to the existing units at Ramagundum Thermal Power Station requires blasting of large volumes of rock very close to sensitive installations like Turbo generator, Generator transformer and Power cycle equipments. Levelling of the areas and excavations for footings are, therefore, to be carried out cautiously. The existing sensitive installations should be protected against ground vibrations and flyrock. The paper describes the details of a few of the many blasts carried out successfully wherein the ground vibrations were restricted and flyrock was avoided.

INTRODUCTION

National Thermal Power Corporation Limited (NTPC), a Government of India Enterprise with a vision to become one of the world's largest and best power utilities, continued its excellent performance on financial, operational, project execution and environmental fronts. NTPC's total installed capacity is 20,844 MW. Data monitor, UK has ranked NTPC as the sixth largest Company in the world in terms of thermal generation and second most efficient in capacity utilisation on the basis of 1998 data. NTPC is making an all out effort to realise its vision of becoming a 40,000 MW plus company by 2012. As a step towards this vision, one 500 MW unit

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is being added at Ramagundum Super Thermal Power Station which has already an installed capacity of 2100 MW (3*200 MW + 3* 500 MW).

NTPC-Ramagundum station is situated on the banks of river Godavari in Karimnagar District of Andhra Pradesh across coal pit head of Singareni Collieries Co. Ltd., and is known for its all round excellence in power generation, plant load factor, environmental management, safety and human resource development. The station supplies power to Southern grid which comprises of five State electricity boards (viz., Andhra Pradesh, Karnataka, Tamilnadu, Pondichery and Kerala), two other central power utilities (viz., Neyveli Lignite Power Corporation and Nuclear Power Corporation) and a few independent power producers. The average peak power demand in Southern grid is 500 MU while average supply is 440 MU. There is always a gap between demand and supply. Supply being less than demand, the grid operates at low frequencies at almost all times of the day. To cater to the growing demand for power in Southern grid, the 7^{th} unit of 500 MW is being added. The unit under construction is scheduled to be in commercial operation by the end of February, 2005.

EXISTING FACILITY AND THE TASK

The existing plant has 6 units and was built in two stages. First stage is consisting of 3 units each of 200 MW and the second phase is consisting of 3 units each of 500 MW capacity. The existing arrangement of turbo generators, boiler plants and associated transformer / switchyards is shown in Figure 1.

The seventh unit, a 500 MW unit, is being added as continuation to existing three 500 MW units. The main power house having turbo generator (TG) hall of 34.0 m span (AB bay) and power cycle equipment bay of 10.0 m span (BC bay) is envisaged to be extended to house seventh unit

TG and power cycle equipment. The proposed extension is shown in Figure 1. From Figure 1, it can be seen that the foundations for TG building, generator transformer, station transformer, TG, power cycle equipment, steam generator, and mills are coming in close proximity to operating units. Various ground levels presently existing prior to start of construction of stage - III are indicated in Figure 1.

The locations of various footings / foundations and envisaged finished ground levels for seventh unit are indicated in Figure 1. To achieve these ground levels, site levelling involves about 150,000 cum. of earth removal and about 30,000 cum. of excavation in rock requiring blasting is to be carried out adjoining to running units. Further, for founding various facilities, excavation of 70,000 cum. in rock requiring blasting is to be carried out at depths varying from (-) 1.50 m to (-) 10.0 m. Therefore, a total of about 100,000 cum. of excavation in rock requiring blasting is to be carried out adjoining a running plant.

As per Geo-physical survey, the soil layer varies from 0.4 to 1.2 m in depth. The soil layer is under lain by bed rock consisting of thick sandstone. The sandstone is characterised by P-wave velocity of 2200 - 2500 m/sec indicating that it is more or less uniform through out the area and is saturated with water. Average value of elastic constants of the sandstone are:

Young's Modules (E)	:	127×10^5 KN/ m^2
Shear Modules (G)	:	59×10^5 KN/ m^2
Poisson's ratio	:	0.073

The borehole data are given in Figure 2.

CRITICAL INSTALLATIONS SENSITIVE TO BLASTING

The blasting operations should be carried out in such a manner that it must not and should not

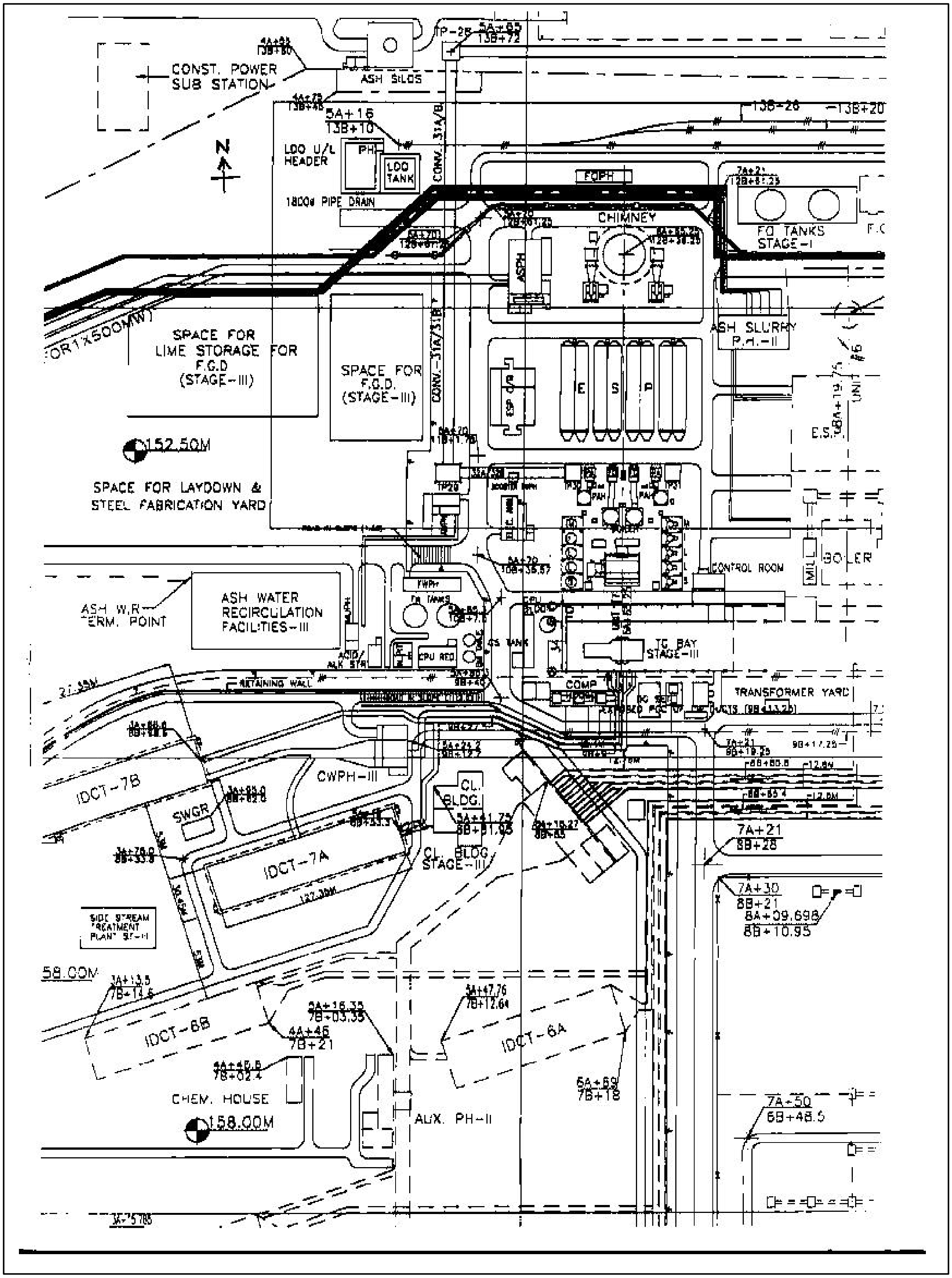


Figure 1: Existing and Proposed arrangement of facilities at NTPC Ramagundum

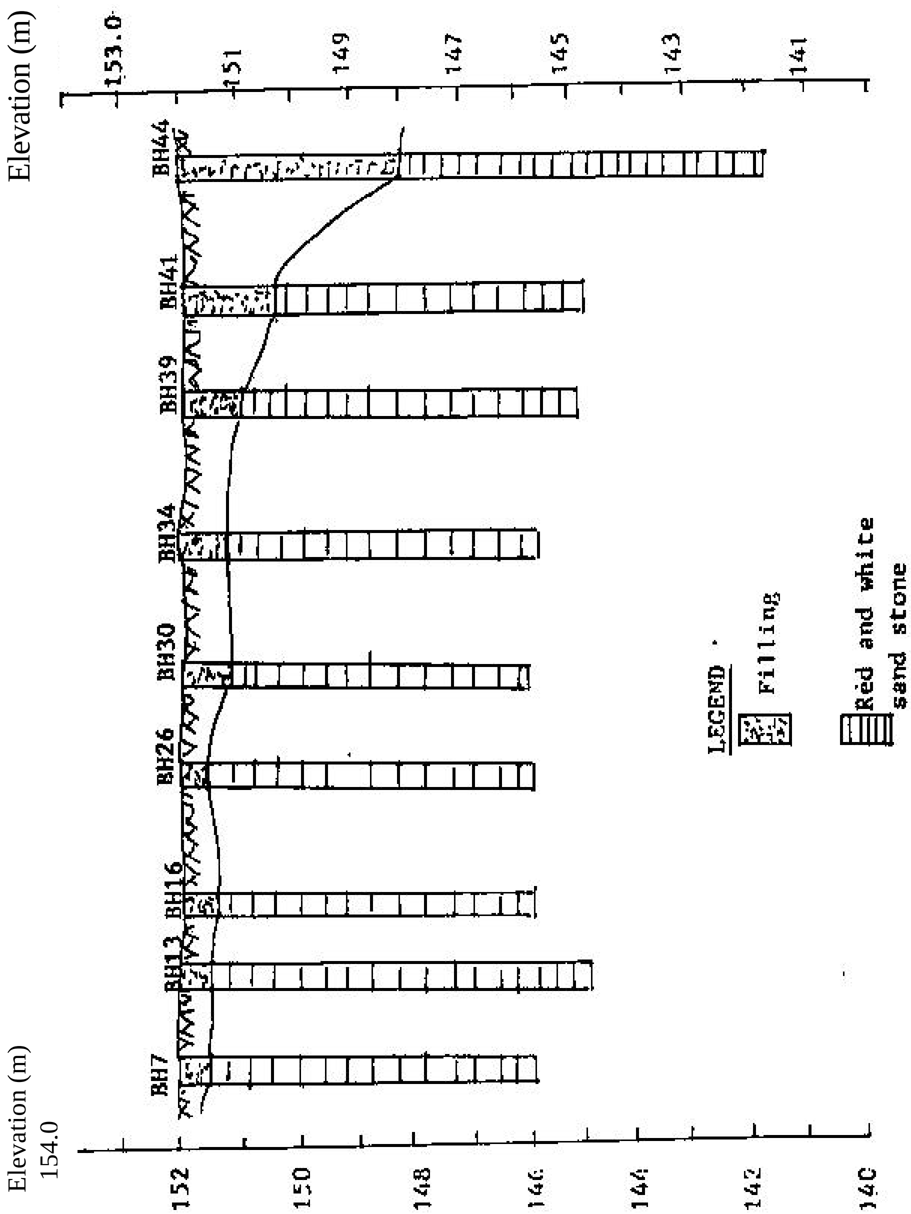


Figure 2: Soil Profile along NS direction NTPC Ramagundum Stage - III Main Plant Area.

affect the smooth and safe operations of power generation through NTPC-Ramagundum area. Some of the sensitive areas as declared critical (shown in Fig. 3) for blasting operations by the NTPC-Ramagundum authorities comprise of;

i. Turbo generator (TG) located at a distance of 40.0 m, and unit transformers situated at a distance of 26.0 m from the Eastern edge of the Main Area.

ii. Circulating Water (CW) Pump House housing seven pumps each of 30,000cum./hr capacity common to (3* 500 MW) stage - II, situated at a distance of 20.0 m from the Western edge of Main Area.

iii. TG hall column foundation F1 at a distance of 6.0 m from running 6^{th} unit TG hall.

iv. Common Fuel oil Tanks and common ash slurry pump house for stage - II located at a distance of 20.0 m from culvert foundation.

v. Coal Mill foundation at a distance of 8.0 m from 6^{th} unit control room.

vi. Chlorination buildings at a minimum distance of 18.0 m as the blast for cooling towers of 7^{th} unit progresses.

FACTORS TO BE CONSIDERED WHILE BLASTING IN THE CRITICAL AREAS

As the blasting sites are very close to the sensitive installations, the following factors are to be considered while planning the blasts:

i. Ground vibrations.

ii. Fly rocks. (The porcelain insulators of transformers, particularly, are easily prone to damage.)

PLANNING THE BLAST

In order to avoid the above said problems, proper planning is essential. The following factors are to be considered while planning the blasts.

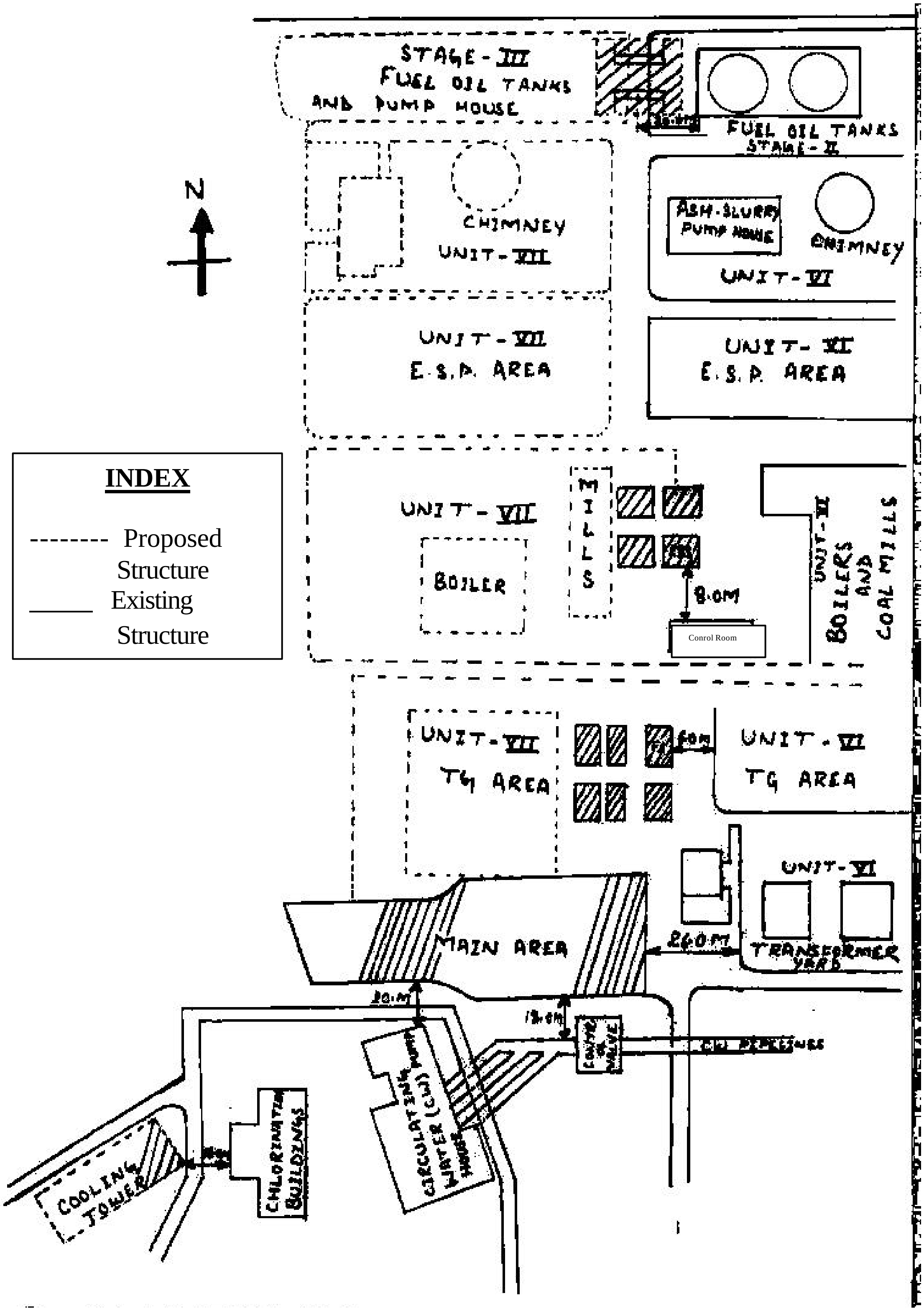


Figure 3: Location of Blast Areas with reference to Sensetiveness (Not to scale).

i. Blast geometry: Choosing proper burden and spacing is essential so that the rock is well fragmented, but not thrown much.

ii. Charge factor: Too high a charge factor will result in fly rock while a low charge factor will result in poor fragment size.

iii. Stemming: Ensuring adequate depth of burial of the charge so that while good top breakage is ensured, ejections of fragments at high velocities are avoided.

iv. Relief: Blast should have adequate relief. The direction of movement of the rock must be regulated.

BLASTS IN CRITICAL AREAS

The blasts in the Main Area had free face with a maximum height of 7.5 m while the blasts in other areas were mainly for footings (no free face available), the depth varying from 4.5 - 5.0 m. While the total charge quantity in the Main Area blasts were of the order of 800 Kgs., blasts for footings used about 125 - 150 Kgs. of explosives. A typical blast in the Main Area and two blasts for footings are described below. Other blasts were similar to the above except for some minor variations.

BLASTS IN THE MAIN AREA

Blasting was started in the main area from the Western end (farthest from TG area and the transformer yard) and progressed towards East. On the basis of a few initial trial blasts, the following parameters were chosen:

1.	Hole diameter	:	41/2" (115 mm)
2.	Inclination	:	20^{o}
3.	Sub grade drilling	:	0.3-0.5 m
4.	Burden and Spacing	:	2.5 m * 3.25 m
5.	Bench height	:	7.0 - 7.5 m
6.	Stemming length	:	3.0 - 3.3m
7.	Max. Charge per delay	:	30 - 58 Kgs.
8.	Charge factor	:	0.6 - 0.7 kg/m^3
9.	Shock tube down line	:	200ms

10. Surface shock tubes : 17ms and 42ms

A hole diameter of 21/2" would have been better, but due to non-availability of drills of that size, 41/2" diameter was adopted. As the face reached within 15-20m of the Eastern edge, the face direction was changed and the blasting was started from the Northern edge so that material would move only towards the open area in the front and not towards East. Otherwise, the Eastern edge could act as a free face and some material would move forward towards transformer yard and TG area of the running 6^{th} unit thereby causing damage, resulting in stoppage of power generation. However, as the rock in the NW-NE-Eastern edge was steeply slopping, it was not possible to drill with the available drilling machine. Therefore, top soil was dumped to a height of about 1 to 1.5 m in this area so that a level ground for the machine to stand on was available to the extent possible. Even with this arrangement the toe burden was around 6.5 mts. The edge holes were positioned in such a way that with an inclination of 20^0, the toe burden was reduced to around 3.6 to 3.8 mts. The direction of initiation was also adjusted such that the rock moved away from the East edge. With this amount of burden, and with a proper amount of bottom charge, the toe was well fragmented but no movement towards East occurred. The blast could be well excavated but for a few boulders. This process was continued till the limit line towards South edge was reached. Throughout this phase, there was no flyrock and excavation was smooth. In order to ensure that no splinter material from blast would get ejected, the top and also the face of the bench were covered with old conveyor belts well overlapped (Covering mats are not presently available). Sand bags were placed over the conveyor belt with a covering density of 80 kg/m^2. The details of a blast at NW edge and typical initiation pattern is given in figure 4 and 5 respectively.

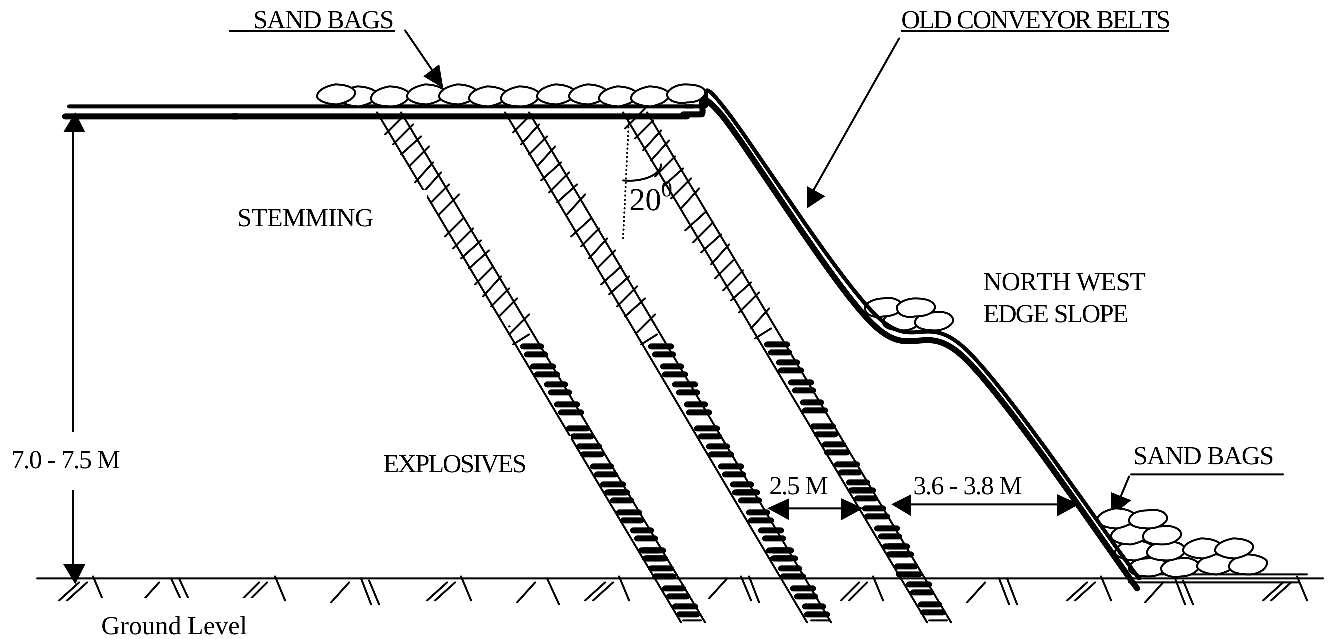


Figure 4: Details of a blast at NW edge (Not to scale)

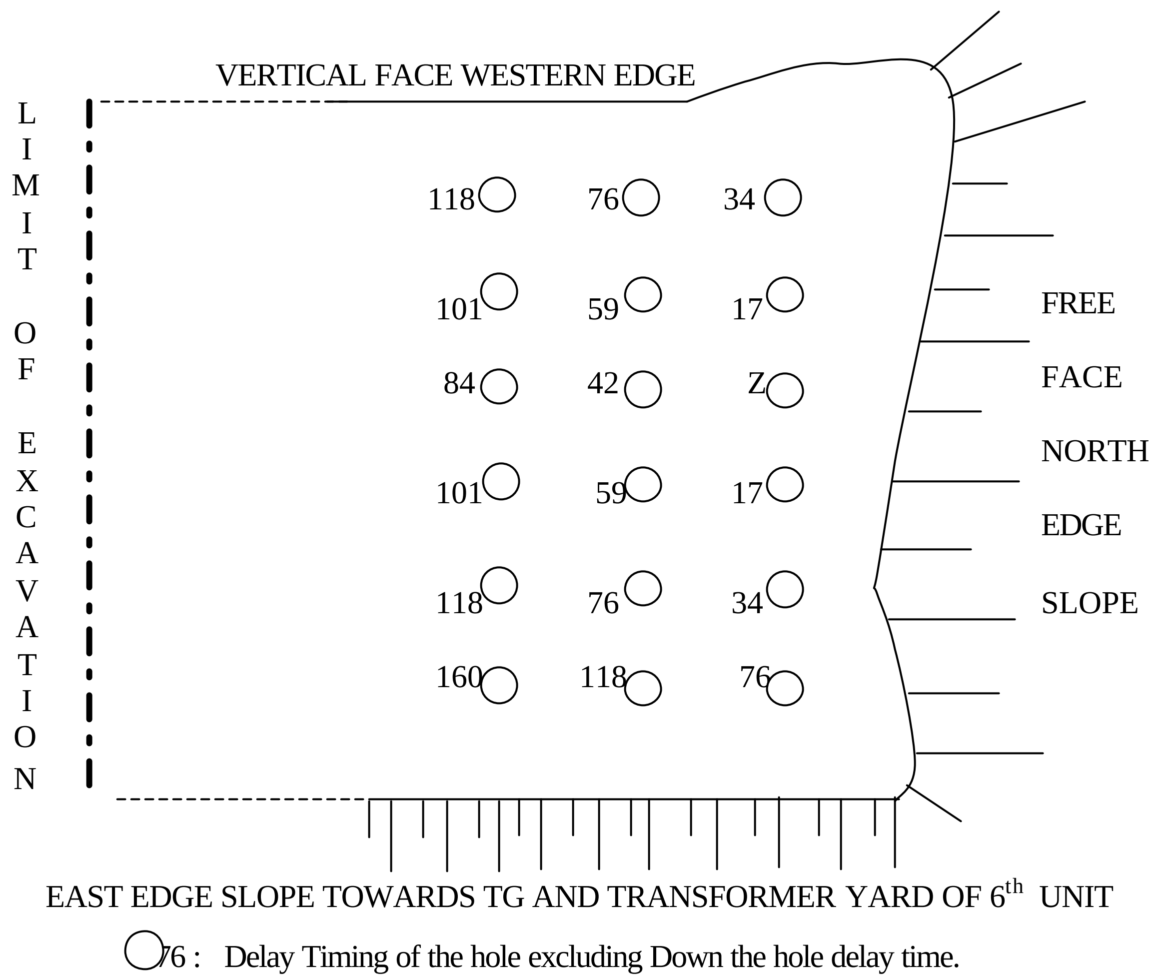


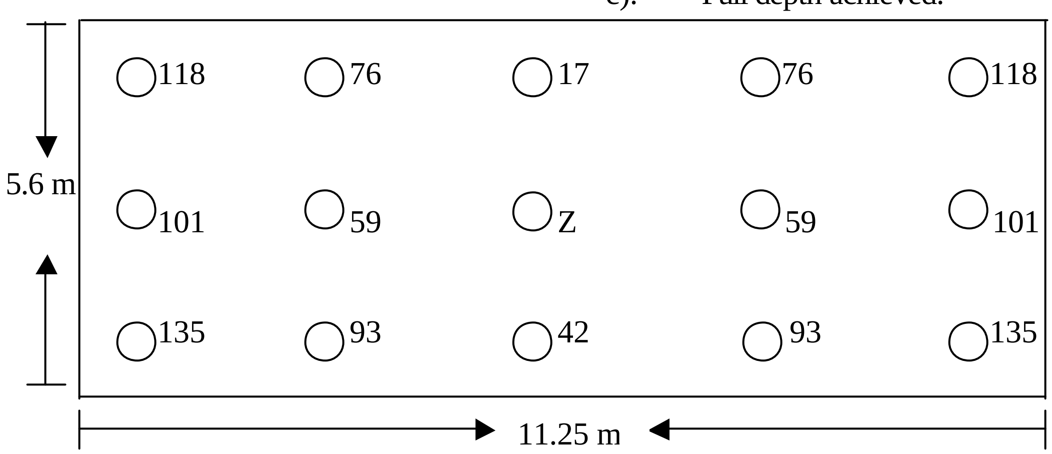
Figure 5 : Blasting initiation pattern at the Main Area.

BLASTING FOR FOOTINGS

In case of blasting for footings, the problem of flyrock is more since blasting is done without any free face (except ground surface). The details of blasts for footings F1 and E33 are given below in Figure 6 and Figure 7 respectively. In the initial blasts, there was fly rock within an area of 30m radius all round. Hence, two layers of belts at right angle to each other were used. The sand bag density was also increased to 100 kg/m ^{2} of area blasted, while reducing the charge factor to 0.50 to 0.60 kg/m ^{3}. The blasts resulted in proper fragmentation and full depth was excavated. There was hardly any fly rock in these blasts.

Description of Column footing F1

1.	Pattern	:	2.0m *2.5m
2.	Hole depth	:	4.0m
3.	Depth to be achieved	:	3.6m
4.	No. of Holes	:	15
5.	Quantity of explosives	:	125 Kgs.
6.	charge factor	:	0.55 kg/m^{3}
7.	Down the hole delay	:	250ms
8.	Surface delay	:	17ms and 42ms
9.	Distance from existing structure	:	6.0 Mts.
10.	Remarks	:	a). No back break. b). Good fragmentation achieved. c). Full depth achieved.

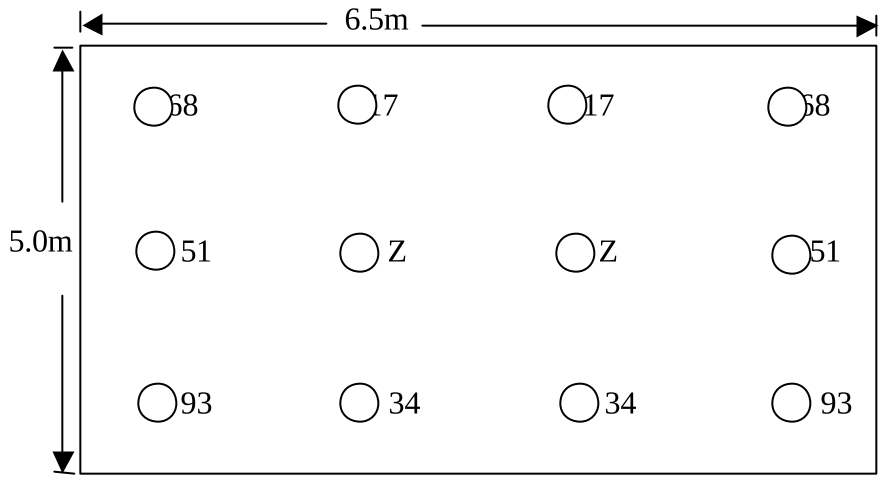


42 : Delay timing of the hole excluding Down the hole delay time.

Figure 6: Initiation pattern for footing F1.

Description of Column footing E33

1.	Pattern	:	2.0m *2.0m
2.	Hole depth	:	4.6m
3.	Depth to be achieved	:	4.2m
4.	No. of Holes	:	12
5.	Quantity of explosives	:	102 Kgs.
6.	charge factor	:	0.7 kg/m^3
7.	Down the hole delay	:	250ms
8.	Surface delay	:	17ms and 42ms
9.	Distance from existing Structure	:	8.0 Mts.
10.	Remarks	:	a). No back break. b). Good fragmentation achieved. c). Full depth achieved.



17 : Delay Timing of the hole excluding Down the hole delay time.

Figure 7 : Initiation pattern for column footing E33.

GROUND VIBRATIONS

The ground vibrations were controlled by delaying each hole and also limiting the charge in the hole. A maximum peak particle velocity (ppv) of 0.47 inch per second (46.5 Hz.) was obtained at the ground level of cooling water pipe lines at the nearest distance of 13m when the blasting was done in the Main Area. The vibration report of the blast is shown as Figure 8. The maximum ppv at the Transformer yard (at 26.0 m from the blast in the Main Area) was 0.24 inch per second.

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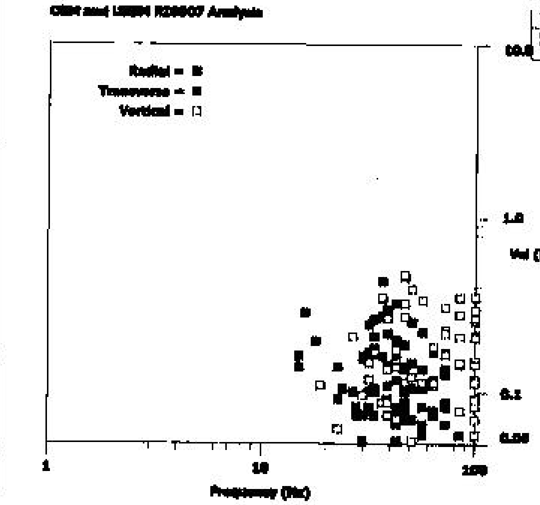
VIBRATION REPORT

Event Name: 208C9E0K
Recording Time: 14:00:40
Recording Date: 12-09-01
Project: RSTPS, VII UNIT AREA, SITE LEVELLING WORK
Client: NTPC - RAMAGUNDUM
Location of Instrument: COOLING WATER PIPES
Operator: SHAIK SUBHAN
Notes: BLAST NO.8, Blast in NW edge of Main Area.
Blast to Sensor Distance : 13.0Mts.
Maximum Weight per Delay : 30.0 Kgs.

Peak Measurements

	Vertical	Transverse	Radial
PPV (in/s)	0.47	0.26	0.43
Freq (Hz)	46.5	34.1	36.6
Time (ms)	260	268	268
PPA (g)	0.36	0.14	0.26
PPD (in)	0.0016	0.0012	0.0019
PVS (in/s)	0.6 @ 267.6ms		
PSPL (psi)	0.0011819 (112.2 dB) @ 325.2ms		
PSPL Freq	51.2Hz		
Sensor Test	Passed	Passed	Passed



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System Configuration
Serial Number: V2-H310208
Calibration Date: August 31, 2000
Model: VMS-2008
Geo Trigger: 0.10(in/s)
Mic Trigger: (105 dB) .000535(psi)
Record Time (s): 1

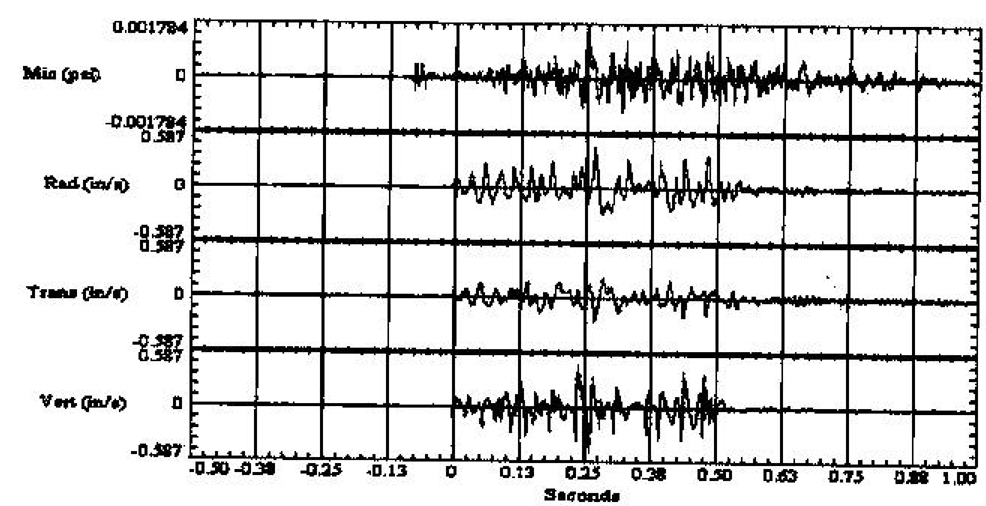

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Figure 8: Vibration Report of NW edge of blast.

The monitored values for the blasts in the main area were in general well below the standard and prescribed limits. The monitored values of peak particle value for blasting for footings were of the order of 0.25 inch per second.

FLYROCK

The flyrock has been totally minimised by having a proper stemming column which did not vent out the gases prematurely. The use of conveyor belt and sand bags minimised the possibility of any small pieces from flying.

CONCLUSIONS

While blasting close to sensitive installations, ground vibrations and flyrock are to be reduced mainly by having a proper blast design. Burden chosen should be such that the gases are confined effectively for sufficient period so as to shear the rock at toe level and move the same. Proper stemming of sufficient height will ensure that no premature venting of gases takes place, as otherwise the venting will result in flyrock. Use of individual delay for each hole with bottom initiation and restricting the charge to the minimum ensures that charge weight per delay is under control thereby reducing the vibrations to within limits.

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