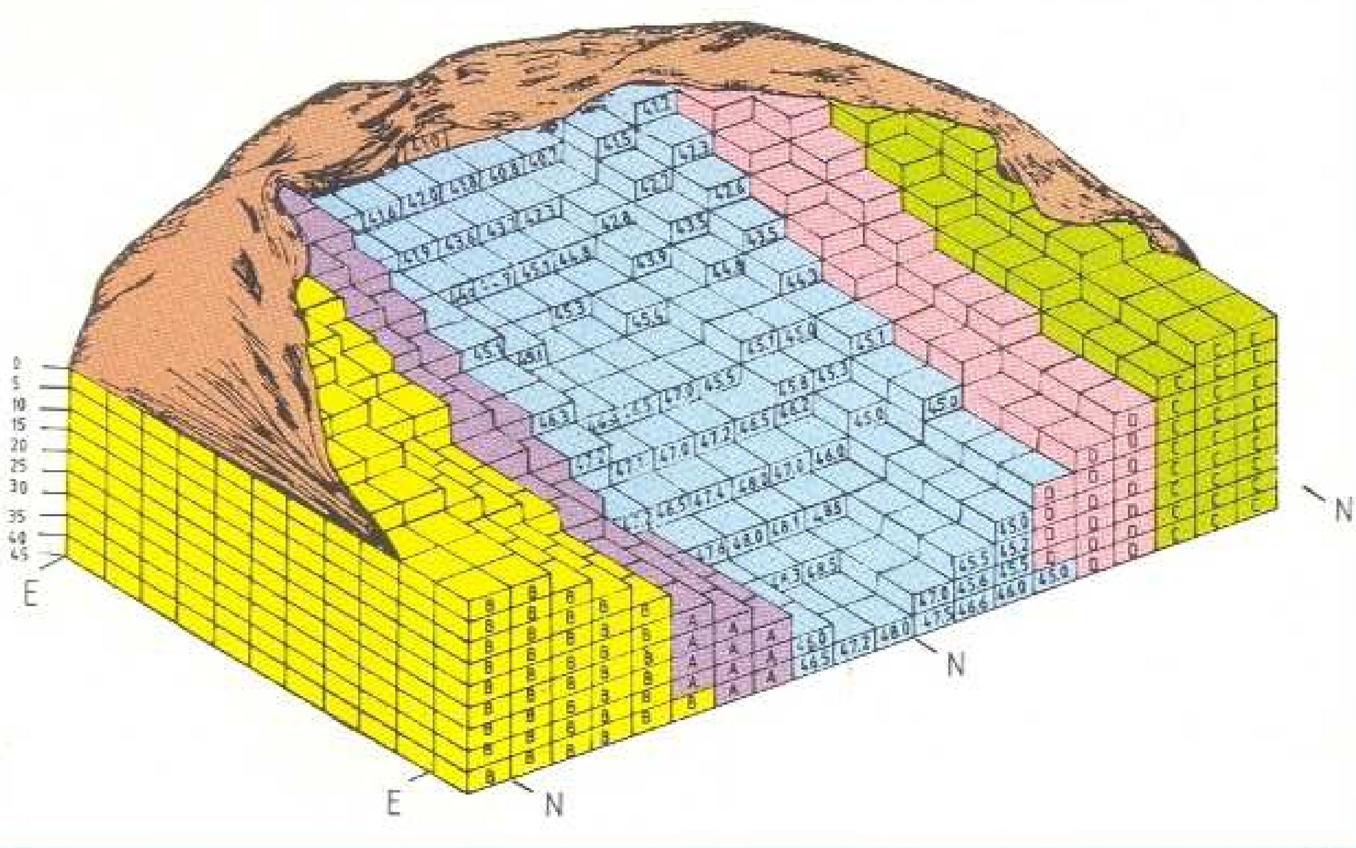
National Council for Cement and Building Materials

COMPUTER AIDED MINE PLANNING



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NCB TECHNOLOGY DIGEST

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1.0 INTRODUCTION

MINING of raw materials constitutes one of the basic activities in cement industry. For cement manufacturing operations to be economically viable, it is absolutely essential that the exploitation of raw materials is accomplished at the minimum cost over a maximum period. Especially, in modern large capacity cement plants, the process and raw material requirements being increasingly stringent, the mining also has to conform to narrower limits. This, in turn, dictates comprehensive planning comprising long-range plan and short-range plan for the effective transformation of the heterogeneous quarry minerals into a homogeneous raw blend. The long-range plan covers reserve estimation, pit limit design, stripping ratios and investment planning while the short-range plan defines the intermediate steps required to reach the final pit limits under physical, operating and legal constraints.

With the advent of computer, it has now become possible to harmonise the various related parameters and achieve rational exploitation of the deposits, exercise better quality control, and accomplish optimum utilisation of the material mined, with due regard to the plant requirements. The present Technology Digest briefly deals with the techniques and methodology of computer aided mine planning developed by NCB.

2.0 DEVELOPMENT OF A GEOLOGICAL MODEL

A computerised data base system enables documentation, and retrieval of exploration and blast hole data in a systematic and scientific manner.

The first step in developing an open pit mine planning system is development of a mineral inventory by shaping a geological model of the deposit, duly outlining the topography, subsurface geology and mineralisation of the area. The deposit is segmented into a multitude of blocks of small, regularly shaped unit volumes with the coordinates and elevations assigned to locate them in space. Physical characteristics, such as rock type, competency and grade are ascribed to each of these blocks (*see* Figure on cover page).

2.1 Computer-based Estimation of Mineral Reserves and Grade

The key phase in developing a mineralisation inventory is grade prediction. Software have been developed for various methods of evaluating reserve and grade. Of the numerous techniques, cross-sectional, triangular and polygonal methods are most common. Selection of the method in a given situation will, however, depend on the deposit characteristics and its intricacy, extent of exploration, probing pattern, etc.

2.1.1 *Polygonal and interpolation techniques*

In the widely practised polygonal method of estimation, the principle of nearest point is adopted. Depending on the mineralisation controls, this technique can be modulated to incorporate geological complexities.

The principle of gradual changes assumes consistently uniform changing conditions between sample points. Inverse distance interpolation is the most common gradual-change technique followed by the mining industry. It uses simple algorithms for weighting the influence of all surrounding samples upon the block being evaluated. More weightage, however, is assigned to the nearer samples.

2.1.2 *Geostatistical techniques*

Geostatistical methods provide sound theoretical and practical basis for conception of the area of influence of a sample, the sub-surface continuity and the lateral changes in mineralisation. With the advent of computer it has now become possible to employ kriging method which is one of the most reliable geostatistical techniques for computation of mineral grade. It involves assigning weighting factors to sample values, which depend upon the geostatistical parameters of the deposit and the geometry of the sample points relative to the block being estimated. It also provides a measure of the probable error associated with the estimates at each point. The basic tool for geostatistical analysis is the semi variogram. After estimating the grade of blocks and variance of the deposit, kriging plan (Fig. 1) of the whole deposit indicating the grade in each of the slices can be prepared.

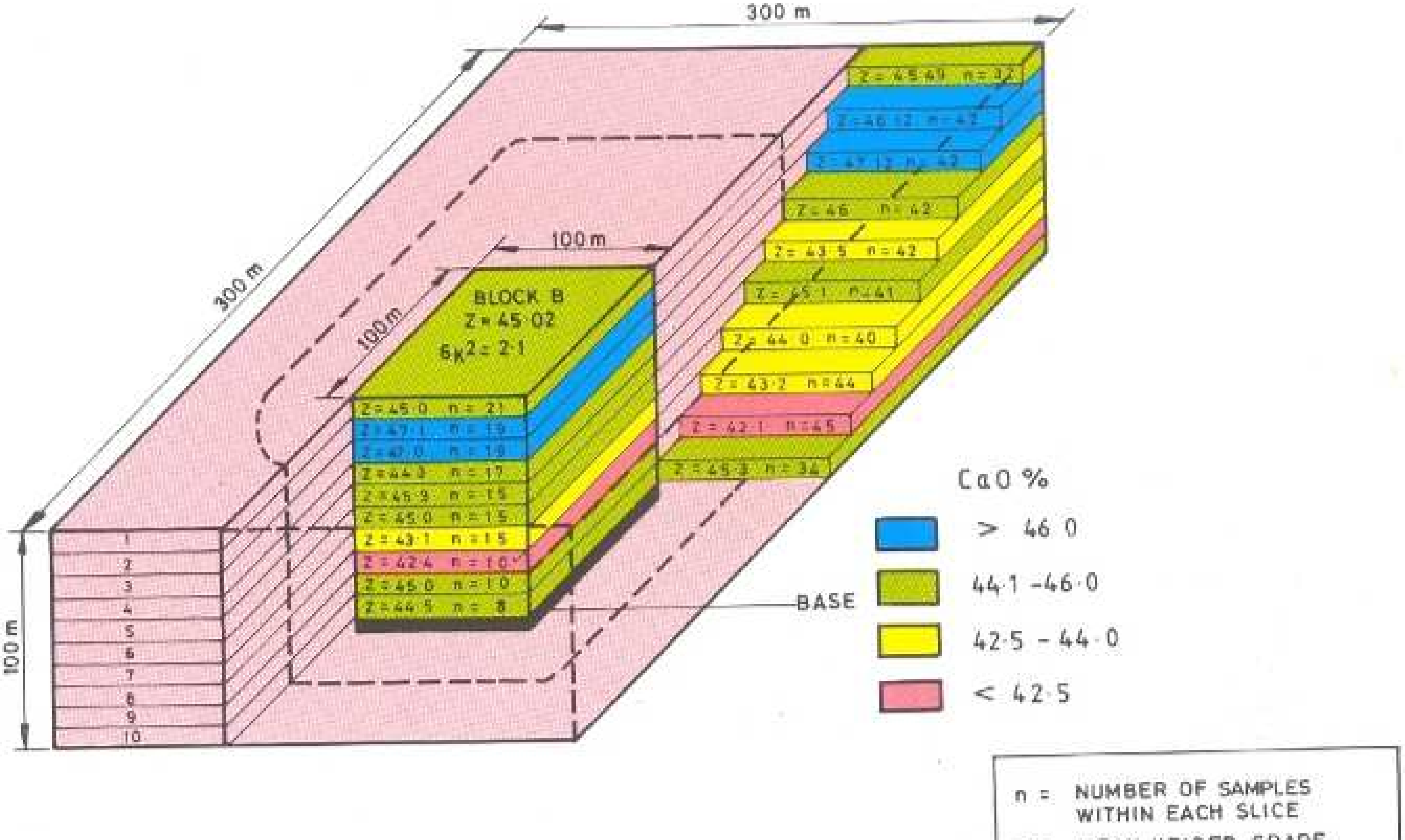

FIG.1 KRIGING PLAN

3.0 COMPUTERISED PIT DESIGN

Derivation of pit limits follow the development of a conceptual model of the mineral deposit. An optimum pit design is one in which all the components generated satisfy certain pre-determined economic criteria dependent on waste-to-ore ratio, operating costs, profit, etc. Two computerised pit design techniques are generally known, the incremental and the floating cone optimiser.

In the incremental approach, the computer calculates and reports tonnes and grades within an increment of the bench outlined by the engineer. The final design is built up by combining profitable increments.

The multiple cone technique provides for a simulated removal of material in small or large pushbacks while maintaining the required pit slopes and providing for operating and legal constraints.

4.0 MINE LAYOUT MODEL

If the blending ratio between materials coming from selected districts of the quarry could be maintained constant over a cement plant's life span, the mining equipment could be selected for their minimum production capacity and at the lowest investment cost. To achieve a constant blend ratio, an optimum bench layout has to be arrived at by systematic variation of the bench floor and bench height, until the average variation of grade from bench to bench is minimum. The bench is divided into working blocks of different qualities which can be blended to maintain an average acceptable grade of the run-of-mine. Figure 2 shows the block map of a bench with individual blocks of 50 × 100 m size, and designated with the assay ranges on a given probability level.

Further, for each operating block, the front orientation, burden and length of face for each blast is also designed for arriving at the optimal mine layout.

5.0 PRODUCTION SCHEDULING MODEL

The objective of a production scheduling model is to determine the most convenient schedule for the exploitation and stockpiling of a mineral deposit. The model covers division of the mine into operational

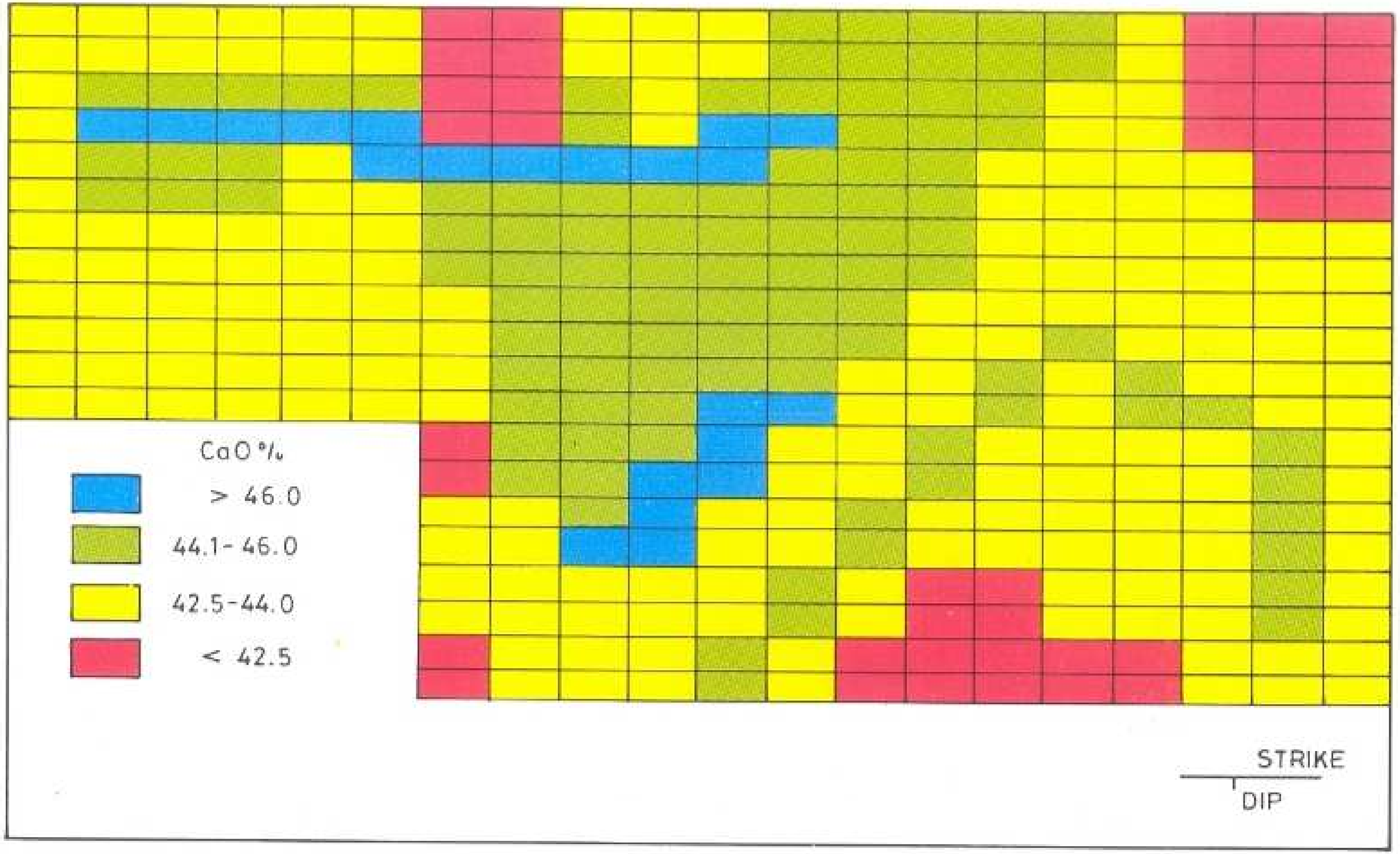

FIG. 2 BENCH MAP SHOWING THE DISTRIBUTION OF 50 x 100 m BLOCKS OF VARYING GRADES

phases and the timing of mining in each phase. The data base for forecasting will be a combination of all available blast hole information along with geological reserve blocking. The schedules are determined based on the mining rates. Software are available which can assign digging capacity to each operational phase, and haulage cycles are added by bench in each phase and a schedule of ore tonnes, ore grade, waste removal and haulage track requirements is produced. If the objectives are not achieved, the equipment are re-allocated or new capacity added until an acceptable schedule is produced. The schedules once made are constantly updated based on any additional data and information acquired through feedback analysis.

6.0 EQUIPMENT SELECTION

Computers facilitate systems simulation in equipment selection and provide objective analysis of the interaction between various equipment. Computer simulation of motion provides a means for evaluating and comparing different types of wheeled equipment, such as trucks, locomotives. The model for excavation and loading dynamics supplies a production study including the volume of material excavated, theoretical capacity and actual capacity of the loading unit.

Computer models for evaluating alternative pit haulage schemes reduce the risk involved in the selection and assignment of equipment in truck and shovel operations.

7.0 COST PROGRAMME MODEL

Computers have long been recognised as a valuable tool for financial evaluation of mining projects. Programmes are available which can be used to estimate operating costs, replacement capital, schedules for operating mines, and sensitivity analysis.

8.0 NCB TECHNOLOGICAL SUPPORT

The above illustrations show that computer serves as a powerful tool in mine planning and design, and provides a quick analysis of the various alternatives. It reduces the drudgery of manual calculations, produces more accurate forecasts and provides timely analysis of numerous management options, resulting in significant cost savings. NCB has been keeping itself abreast of the latest developments in computer applications for mine planning within the country and abroad. Accordingly, it can guide and render technical assistance in the various aspects of mine planning, such as interpretation and analysis of geological data, grade prediction and reserve estimation using conventional and geostatistical methods, determination of pit limits and production scheduling, etc.

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