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INNOVATIVE COMPUTERIZED METHODS WITH OPERATIONS RESEARCH TO IMPROVE INDIAN COAL MINING

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ABSTRACT

Because of geological incongruities of reserves, planning and operations of mines are different in each case. A research study was done from IIT(ISM) Dhanbad for developing computerized method studies for better performance and monitoring of a coal company. The research has also developed models for cost-benefit analysis of improved systems of mining operations on ground realities and database creation. The research was carried out by analyzing existing mines for developing model programs for improvements. India has 320 billion tonnes of coal reserves and it is 7 percent of the reserve of the world. The energy consumption in India is about one-third of the world average and 60 percent of the installed capacity of energy in the country is based on thermal plants. The research has developed data-based computer methods in 14 original models; for result-oriented planning for multi-project scheduling and monitoring. Once, the techno-economics of coalmine reorganization is finalized, viz. programs run, scheduling of activities and monitoring for completion become valuable. Research conducted caused better performance and profit for the company.

KEYWORDS: System Studies; Method Studies; Multi-Projects Format; Database Models; Operating Return; Cost-Benefit Analysis.

1. INTRODUCTION

Industrial organization and entrepreneurship involve innovation (Audretsch and Link et al. 2020). ECL carries out internal audit, secretarial audit, cost audit, statutory audits for assessing and reporting performance. Mine planning and project design are fundamentally dependent on the geological attributes of the reserve. Most crucial problem is that mine reserves are widely varying and so project planning is unique for each mine and different. Comparatively industrial projects design can be implemented in any location on the parameters of equipment. Billions of ₹(Rupees) are spent every year on mining and construction of projects spread all over India. The use of proper scheduling and monitoring techniques can ensure better ROI (Return On Investment) and quick completion of projects. Cost and time overruns of highly capital intensive projects can be checked and even 5% saving could mean millions of Rupees. Proper viable planning can only make multi-project scheduling effective.

Coal reserves are available in almost every country worldwide, with recoverable reserves in around 70 countries. The biggest reserves are in the USA, Russia, China, and India. There are an estimated 1.1 trillion tonnes of proven coal reserves worldwide. In terms of coal production, the total in the world is expected in 2019 to be 7730 Mt, compared to 7,460.4 Mt in 2016. Country-wise ranking with China #1 is programmed to produce in 2019 3520 Mt as against

3,411 Mt in 2016; India in #2 position is expected to produce 716 Mt compared to 692.4 Mt in 2016; the USA in #3 is planned to produce 702 Mt as against 660.6 Mt in 2016.

Major producers of coal in India are CIL subsidiaries and coal blocks allotted to private companies. Coal India Ltd is making profits from opencast mines mainly, overcoming the losses suffered by underground mines. Projects costing above ₹5000 million (1$=₹71 as in Sept 2019) are approved by the Govt. through EFC/PIB and CCEA Environmental clearance is mandatory before the project proposal is posed to Cabinet Committee on Economic Affairs for approval. Coal projects are monitored in the coal companies at the colliery level, area level, and HQ level. Remedial actions, wherever warranted are taken. Figure No-1 shows the Indian coal project approval system.

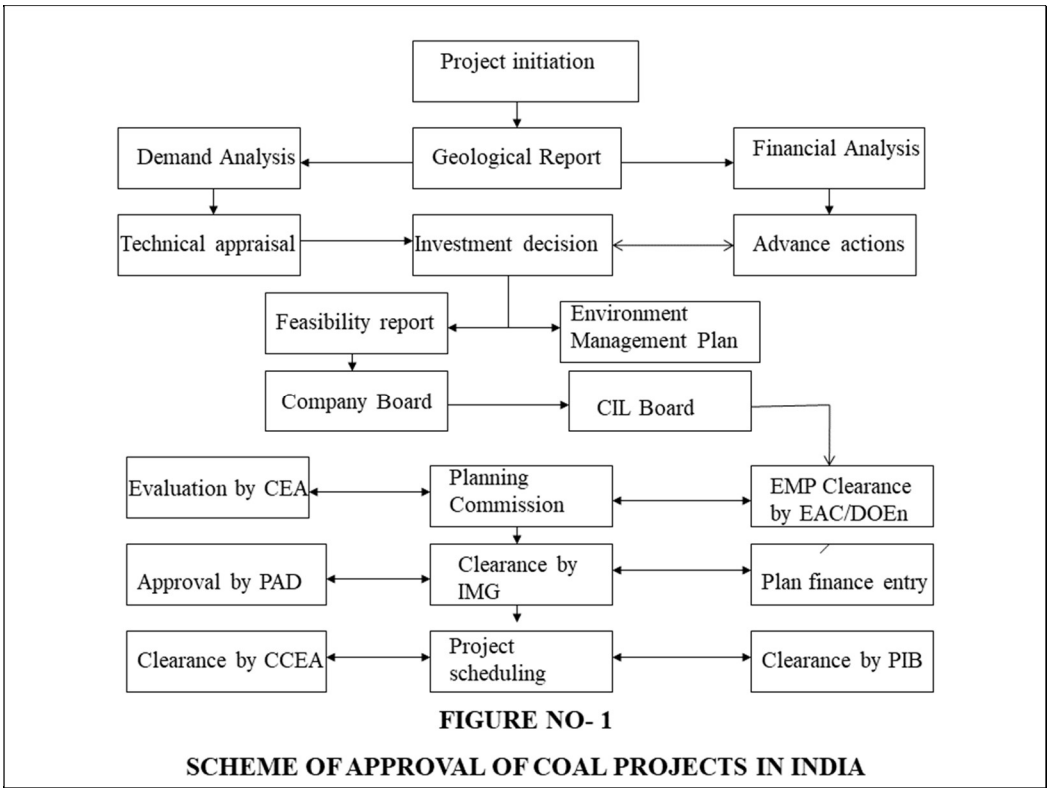

FIGURE NO- 1

SCHEME OF APPROVAL OF COAL PROJECTS IN INDIA

Computer project software and networking through the internet have been growing very fast and some of the recent related developments have more than 330 versions. For the success of multi-project scheduling, as no two mines are alike, because of geological incongruence, every coal mine project should be critically analyzed for improvement. World Coal Demand as indicated by World Energy Council (WEC) by 2020 is 3,723 and by 2030 is 4,757 (Mtoe). All India's production of coal was 675.40 million tonnes in 2017-18 and 2018-19 was 730.35. Target Indian coal production in 2019-20 is 810 mt, but there could be a shortfall and so the result of the study should be useful. Around 87% of India's proven coal reserves total 319.02 Billion tonnes estimated in the country as of 1.4.2018.

The research has developed data-based computer methods in 14 original models. So, applying principles of Operations Research (OR), models have been designed, coded and run. Selection of existing mines to convert in to reorganized projects was emphasized, as new project planning was mostly done by Central Mine Planning and Design Institute under Coal India Limited. Once, the techno-economics

of coalmine Reorganization Project is finalized, viz. programs runs, scheduling of activities and monitoring for completion become valuable. More flexible approach to governance (Sergeeva, N. 2019) is to allow innovation in all respects.

The research in due course has coded the following special model programs, shown in Table No-1, which can help proper planning, scheduling, monitoring, and prioritization of coal projects.

TABLE NO-1: LIST OF COMPUTER MODEL PROGRAMS AND RUNS

SN	Model Programs	Purpose of Model Program
1	**qep**	Quick Evaluation of Projects
2	**bep**	Recalculating BEP, reducing Var. Cost
3	**bep2**	Revised BEP, on Additional. Investment
4	**mps**	Single Project Scheduling Package-Wise
5	**mpt**	Multi-Project Scheduling for Company
6	**scl**	Cost-benefit of Shotcrete Lining in Shafts
7	**stl**	Cost-benefit of Track Steel/RCC Sleepers
8	**dre**	Cost-benefit in Dam Dredging for Stowing
9	**troq**	Opencast Mine Transport Reorganization
10	**eqp**	Selection of U/G Equipment & Scheduling
11	**snet**	Simulation of PERT for Mine Project Scheduling
12	**fecl**	Macros for Updating Financial Scheduling
13	**mbo**	Key task against Management Positions
14	**dew**	Computing. Dewatering Time of a Mine

2. NEW PROJECTS

Since new mining projects are highly capital intensive, techno-commercial evaluation is necessary (Samanta, B.K.1996) for the method to be adopted. So, recent advances in information technology have to be adopted for the correct decision. The research has designed a small model program **'qep'** based on the Expert System (ES) concept and run it with practical field and cost data. Project method A1 is for semi-mechanized Bord and Pillar system with tub loading and haulage. Project method A2 is for mechanized Bord and Pillar system with Side Discharge Loader (SDL) and chain conveyors. Project method A3 is for mechanized Longwall with Shearer, Armoured Face Conveyor (AFC), self-advancing hydraulic support, etc. The objective is to develop the right planning for scheduling and monitoring and it has been found from the output data of ES that cost increased with the size of mine projects. Investment decision of projects [4] should be done on: -

i. Payout time- *i.e. when Break-Even Point is reached, applied here*.
ii. Average yearly payout- *in terms of capital, works, crew, materials, etc.*
iii. Accounting Return or net profit on original investment- *used in this ES, as the main criterion.*
iv. Operating Return- *indicated in the ES annually*.
v. The present worth of Cash flow discounted @10-20%- *used in the E.S for projection over 6 years.*
vi. Net Profit- *is computed excluding taxes and royalties.*
vii. DCF Return- *could be computed from the ES.*

viii. Sensitivity Analysis- *Change in output by a change in input- indicated by higher BEP.*
ix. Actuarial analysis for estimating service life for depreciation- *in CIL for 9 years*.
x. Incremental cost analysis for marginal cost etc. - *could be computed from the data generated*.

Profitability Index (PI) or Return On Investment (ROI) or Discounted Cash Flow (DCF) rate of return is some (Kerzner, Harold 2009) of the indicators of profits. ROI could be computed from: -

$$ROI = a + (b-a)\ \{(a_r-1.0)/(a_r-b_r)\} = 18\% \text{ to } 28\%;$$

Where, a = initial rate of interest, b = higher interest rate, a_r or b_r = discounted receipts / discounted investment = 1.1 to 1.2. ROE or Return on Equity is given by profit after Tax/ Net worth. Run of the program 'QEP' with actual data from mines show: -

1) In the program sample run, with available mine cost data, the Longwall method has shown lower A/C Return 10.75 and so ES has been indicated as less suitable.
2) In favorable conditions, and if we standardize and indigenously manufacture LWPS, it could be the most (Samanta, B.K 1996) suitable method in the future. IRR should be 12% at 85% production.
3) To achieve very high OMS and profitability, Continuous Miner technology with roof bolting could be adopted even in geologically disturbed areas.
4) A/C Return with SDL in B&P method has come 14.93 and so the most suitable method in this study.

Figure No-2 displays the program flowchart of Quick Selection of Projects.

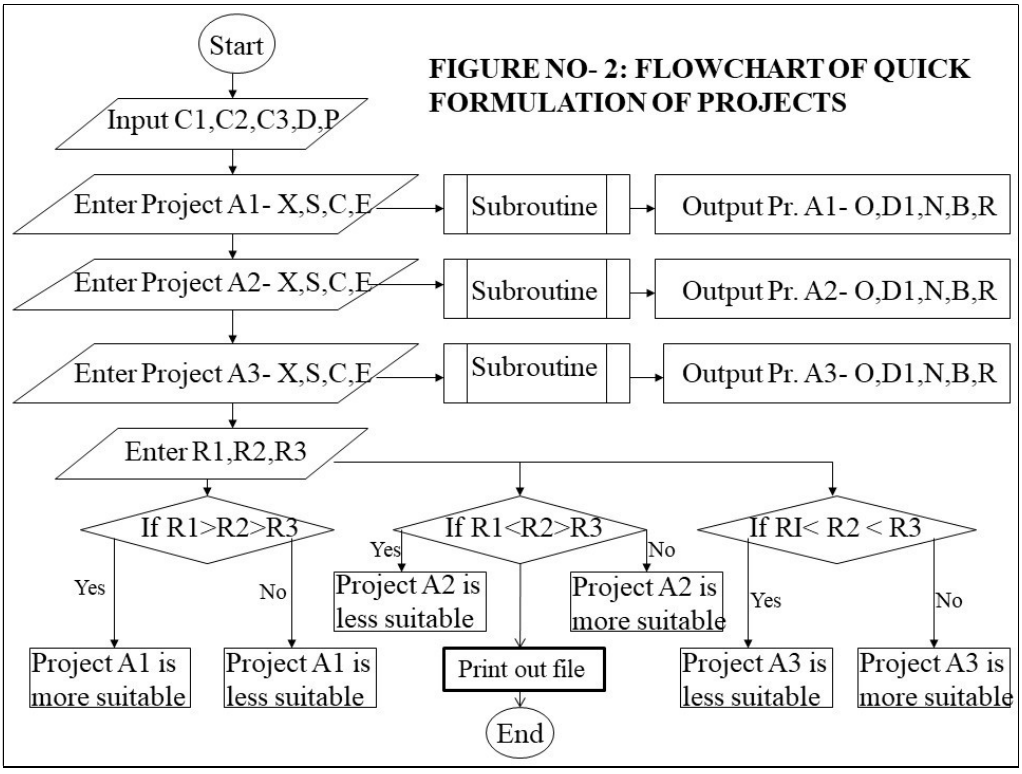

FIGURE NO- 2: FLOWCHART OF QUICK FORMULATION OF PROJECTS

3. REORGANIZED PROJECTS

In planning reorganized projects from old mines, crossing the Break-Even Point (BEP) level of production is essential (Samanta, B.K. & Samaddar, A. B. 2002). The researcher has developed 2 Database model programs, **'bep'** for Recalculating BEP, reducing Variable Cost, and **'bep2'** for Revised BEP, on Additional. Investment for making an old mine viable.

Data were compiled from the cost sheets submitted by the collieries of a company in 3 different months. Since fixed costs and variable costs are not indicated so they are computed and entered into the records. Profit/loss and the fixed cost was computed by:-

PROF_LOS = SAL_PRIC-NET_COS
FIX_COS = NET_COS-VAR_COS+
BRK_EVN_PT = FIX_COS*PR_TPD/(SAL_PRIC-VAR_COS)

If BEP could not be achieved without additional production from mechanization, needing additional investment for the additional production, total BEP changes: -.

TOT_BEP = BRK_EVN_PT+ADL_PROD

It is assumed that 22% of the annual depreciation + interest and 300 is the number of working days in a year. It can be found that an additional investment of ₹1 million could be neutralized with an additional 2 tpd, e.g. as in the PDV_PDV mine. However, this additional investment and ADDL_PROD required would be higher accordingly. Again, the program computed the revised total break-even point of the colliery.

Random checks can be made of any mine in the database on the model program run of **'bep'** for showing TOT_BEP after ADL_INV is made in a mine, without changing databases. The database shows BKL_MRA has TOT_BEP: 723 t and even with ADL_INV: of ₹80 lakhs, like SDL set TOT_BEP increases by only about 56 t

Referring to a database showing KNT_TPS has BRK_EVN_PT of ₹131.42 with VAR_COS of ₹131.42. A random run of the model program **'bep2'** for displaying revised BRK_EVN_PT lessened by 50t, with reducing VAR_COS of the mine is shown without changing databases.

4. COAL MULTI PROJECTS

Regulation and persistence of profits in firms (Desai S, Eklund J E, Lappi E 2020) are important to follow. A system approach is required for the planning of projects, scheduling, and controlling. Since coal mining project activities are differing widely, so they are grouped in standard packages (Samanta, B.K.1996). All the packages are further divided into sub-packages and totaling is made head-wise, applicable for all types of mining, in conformity of budget heads. The model program **'mps'** for computing the entries of a single project and model program **'mpt'** for different projects of a company in a particular month, with budget vs. actual and %schedule vs. %progress for monthly monitoring**.** Combining different activities into common packages and running 'mps' for individual projects and then feeding them into 'mpt' and yielding company-wise output for any month.

Such a single-page summary for a month of project monitoring budget, expenditure, and % schedule and % progress and are very useful for top management and ministry for a quick

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review for deciding remedial actions for slippage. Figure No-3 shows the program flowchart for coal projects package-wise and month-wise.

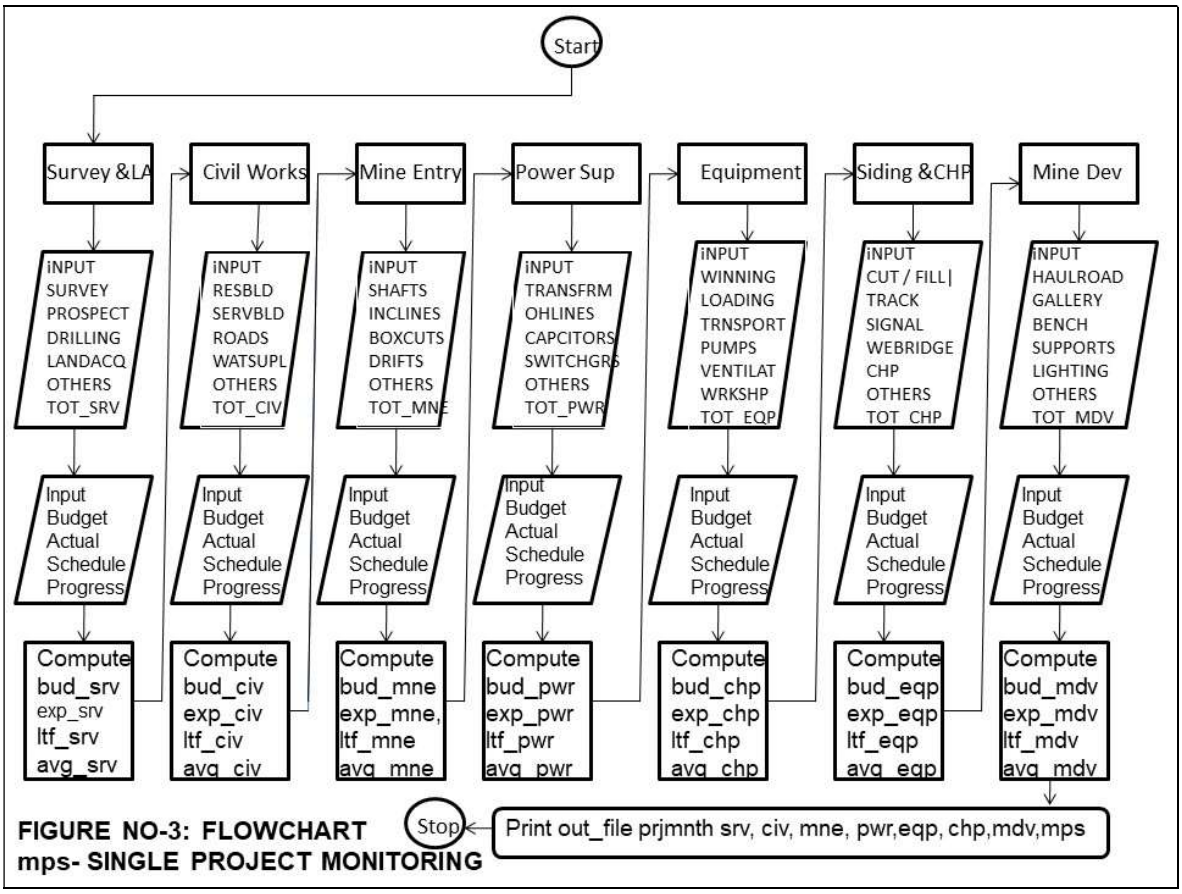

FIGURE NO-3: FLOWCHART mps- SINGLE PROJECT MONITORING

5. COST-BENEFIT FOR IMPROVED METHODS

Improvement of methods and systems could plan better projects to schedule and monitor. Cost-Benefit Analysis before planning, especially new and emerging methods can make successful projects (Noort, D J, and Adams, C 2006). Developed model programs by the research for planning, scheduling, and monitoring can yield successful projects (Mitchell, Paul 2011) and the performance of the company. The model programs accentuate better methods and they can be further modified into software, which was beyond the scope of the research.

5.1 Shaft lining

Indian coal reserves are mostly in hard sedimentary rocks, and mine pits used to be lined only up to rock head. Now, legislation demands lining of shafts, and the method of monolithic lining has become very costly and so the cheaper possibility of shotcrete lining has been examined. The model program run of **'scl'** makes some projections and coded in this program are 'netsave'- expected net saving, 'conlicst'- saving in concrete lining cost, 'exvcst'- saving in excavation cost, 'wincst' - saving in winch and shuttering cost, 'slcst'- shotcrete lining cost, 'diam'- diameter of the finished shaft, 'depth'- of the shaft in m, etc. By realistic input of data, a sample program run with different diameters and depths showing the cost-benefit by applying

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shotcrete lining compared to the monolithic concrete lining is determined. Figure No-4 displays the flowchart of the program for cost-benefit by shotcrete shaft lining.

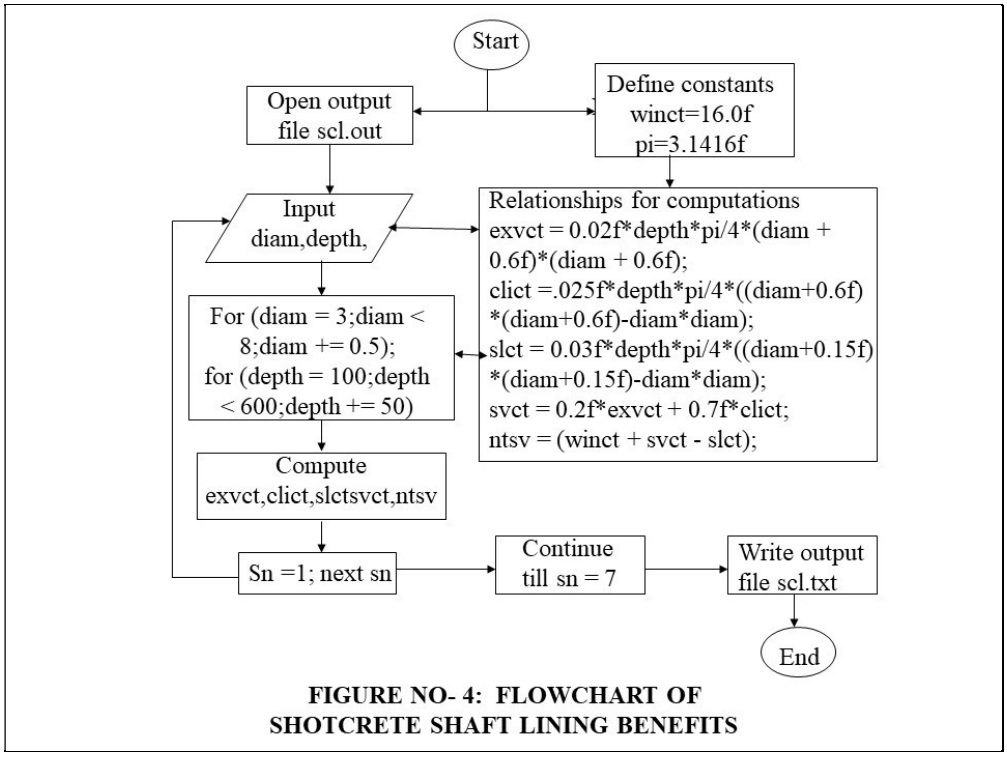

FIGURE NO- 4: FLOWCHART OF SHOTCRETE SHAFT LINING BENEFITS

It could be observed from the program run that approximate cost saving by adopting shotcrete lining, as compared to the monolithic concrete lining, is quite considerable and the savings are high for larger size shafts. In the program run, net savings have been computed, from ₹ 29.38 million for 5mΦ, 100m depths; to ₹ 59.69 million, for 7m Φ, 450 m depth, compared to the conventional monolithic concrete lining in shafts.

5.2 Improved Track and Support

Most traditional underground mines have track haulage as the main coal production transport system. So, in planning and scheduling, a better track system for coal transportation is essential. Model program **'stl'** determines the cost-benefit and accordingly scheduling and prioritization of mines for implementation. In the model program, data given were the price of TS1 - Timber Sleeper 0.61m gauge = ₹20; TS2-Timber Sleeper 1 m gauge= ₹70; SS1-Steel sleeper 0.61m gauge - ₹300, SS2- Steel Sleeper 1m gauge= ₹500. It could be observed from the program run that projected cost saving by adopting steel sleeper was quite considerable and the savings ranged from ₹1.2 to 4.9 million per year.

The **'stl'** model program writes the data according to format statement, like column-colliery, name, TYP- type, NTS- no. of timber sleeper, DCOST- dog nail cost, NSS-no. of steel sleepers= 80% NTS, as life could be 20 years against 4 years of timber found; YRPR- yearly production, and CP-coal price. Then, assignment statement, TC-timber-track cost, SC-steel track cost, type '*'-meter gauge, TTC-total timber-track cost, DSAV- derailment saving, and CB-cost benefits, etc. are coded in the program. It has been established by the computer

program run, that although the price of timber sleeper is 1/5th of the steel sleeper, in the long run, the designed steel sleeper can yield annual savings with less derailment.

5.13 Strata Control Cost Benefit

Among the various methods of stowing for filling voids after extraction of coal, sand stowing is the most prevalent, as compared to costlier crushed stone, pneumatic or high-speed belt stowing, etc. So, sand separation from hydraulic transportation by dredging of dam reservoir has been examined (Samanta, B.K 2006). On approximate capital cost for pumps and pipelines, used in the computer program run, the coded **'dre'** show great benefit. Annual net saving ranged from ₹1.3 million for Maithon- BCCL pipeline to ₹137 million for Maithon- Maithon rivulet pipeline. By pipeline, it is assumed saving of 5 km and ₹15 per m^3 for 1.0 mill. m^3 per year of 'svtk'=₹150 million.

5.14 Quarry Planning Cost Benefit & Scheduling

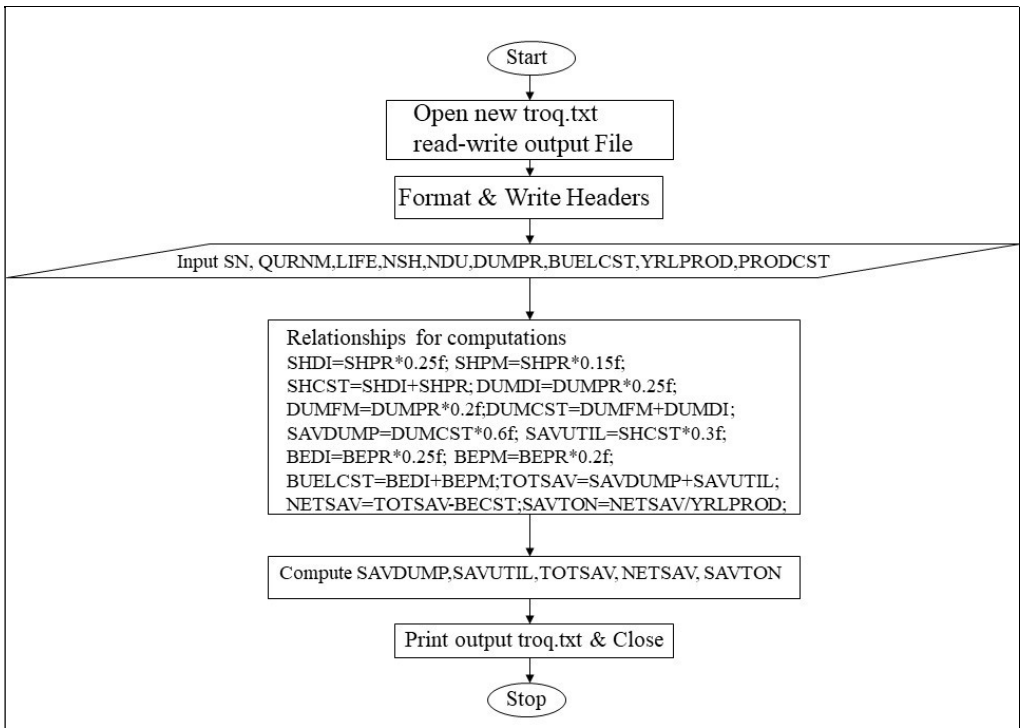

FIGURE5: FLOWCHART OF PROGRAM FOR QUARRY REOGANIZATION

Most open cast mines or quarries practice transportation of coal and overburden by circuitous haul roads, which are very costly to maintain. Intelligent Optimization for Project Scheduling is suggested (Guo H, Zhu K, Ding C, Li L 2010). When the model program **'troq'** was compiled and run, with the layout of crusher, bucket elevator, and bunker with screen for steam and slack coal. The program run output shows accrued savings ranging from Rs.40.10/t, in the RJ-RJM mine to Rs.1175.62/t in the MU-SHP mine. Many other small variables have been discounted and realistic saving could be less. But, irrevocably the fact stands out that there is considerable justification in reorganization to electricity-driven vertical transport in opencast mines, especially small mines. There will be greater utilization of shovels, especially in small quarries. Surplus dumpers and trucks could be shifted to new or other mines resulting in more

production. There should be more OB removal, as haul roads would be solely used for the purpose. Figure No.5 shows the flowchart of cost-benefit by steep transport in quarries.

5.15 Underground Machinery Cost Benefit

There are various types of underground mining machinery available (Samanta, B.K 2018) and so according to the particular mine reserve geology, a database program has been coded and run. The model program **'eqp'** has considered 4 types of equipment packages, most commonly used in Indian coal mines, namely Side Discharge Loader (ESDL), Load Haul Dumper (ELHD), Continuous Miner (ECHMN), and Longwall Shearer with Power Support (ELWPS). Here, prefix E stands for equipment set, for the type of face. The variable names have been declared with codes and data types-namely SLNO, COLLIERY, COE (Cost of Equipment), POC (Production of Coal/y), DIT (Depreciation and Interest), PMT (Power & Maintenance), SC (Store Cost), WC (Wage Cost), OC (Other Cost), PC (Production Cost), CP (Cost of Production), and CB (Cost-Benefit in Rs./t). The cost of equipment has been shown with switchgear and declared in DATA statement, in Rs. Millions – ACNV (Armored Conveyor), BCNV (Belt Conveyor), CCNV (Chain Conveyor), SDL, LHD, CNMN (Continuous Miner), and LWPS. The input data file has been named eqp.dat and its header is formatted, as per statement 5. The Run file is named eqp.txt and the header is formatted as per statement 10.

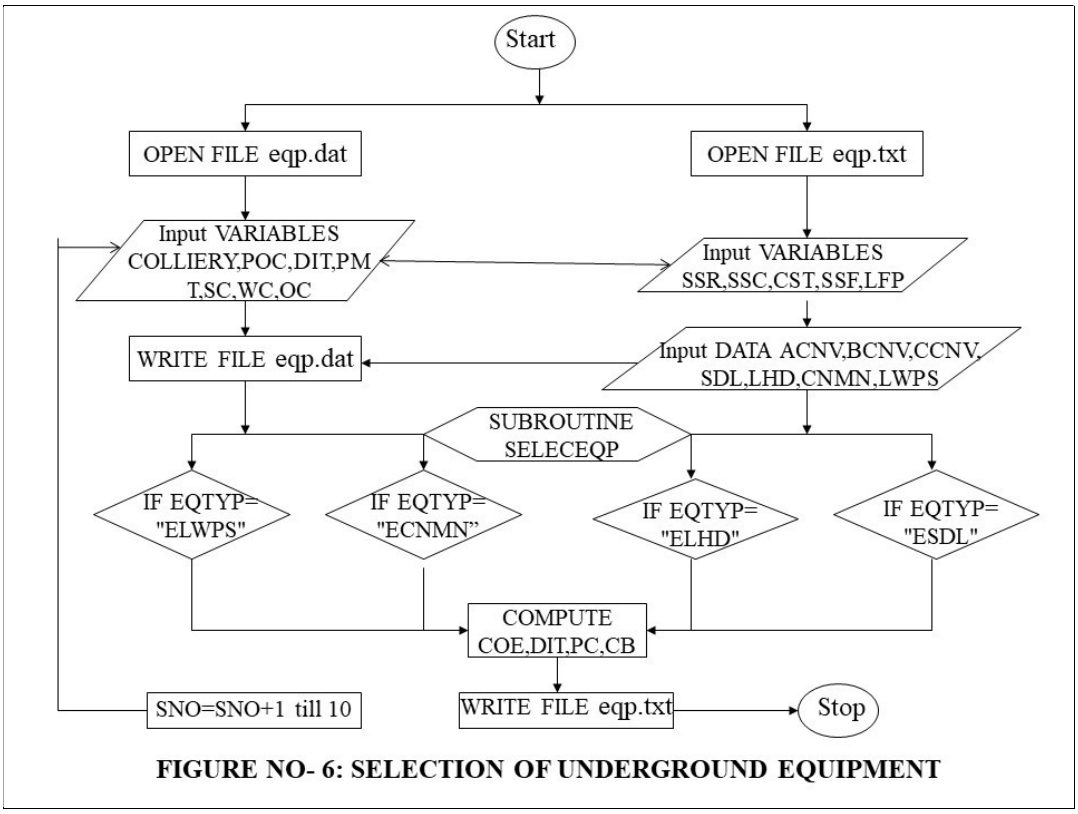

FIGURE NO- 6: SELECTION OF UNDERGROUND EQUIPMENT

The program is designed with a subroutine for selecting Equipment Type, with the input of Shear Strength of roof stone (SSR), coal (SSC), floor stone (SSF), seam thickness (CST), largest faultless panel (LFP), etc. EQTYP selection has been based on the parameters in the program. EQTYP=ELWPS if LFP>100 Hectares and SSR<100 bar; =ECNMN if SSC<20 and LFP>50; =ELHD if CST>5 and SSF>80; =ESDL if CST<4 and SSF>100. Pre-Feasibility

Report can be made using the model **'eqp'** to select the appropriate equipment set. Figure No-6 shows the flowchart of program for selection of underground mining equipment.

6. SCHEDULING & MONITORING MODEL/S

When the cost-benefit analysis is encouraged by a designed program run with realistic data for a new or reorganized method, then planning for scheduling is the logical next step (Kumar C, Banka H & Ramesh D 2016). Coal mine project construction is highly capital-intensive; funding requirement is very often changing for geological and techno-economic reasons.

6.1 Opencast Coal Mine Project

Computerized AON PERT diagram, created on VAX Computer by the set of input data of SNB project. The activity name is followed by duration in brackets, e.g. coal production sec-A. Since the project has been rescheduled, there was very little float, found in the chart. The critical activities are shown by bold lines, on the bar chart, as computed by the compiler. New techniques were applied by the researcher for numerous advantages of reviewing computerized networks, after the first input of data. Review could be done any date, provided all data of revision or reschedule of activities. Activities could be split, deleted, inserted, or even relocated with the change of dependencies, with the change of start dates and resources, the compiler automatically computes, all remaining parameters of the network.

6.2 Underground Coal Project

According to the above system of packages, a project network of an underground mine of ECL, codenamed SAT, was computerized. The project was designed to produce 1.2 Mt of coal per year. 2 new shafts, 7.2 m Φ had been sunk up to Dissergarh seam in the first phase and were being equipped. A pair of inclines was to be driven to the Dissergarh seam also to work the seam in the rise area.

6.3 Capital Budget Monitoring

Because of geo-mining problems, rescheduling has to be resorted to very often and adjusting fund scheduling. Resource allocation as per schedule is essential, like men, money, machinery, and materials of which money is the most important, as it can arrange other resources. The spreadsheet columns and rows are required to be updated every month, a model **'macro'** program has been designed by the researcher for automatic cursor movement, for the input of data, saving, and printing.

Moreover, in the spreadsheet, cell formulae have been incorporated for automatic computing of the assigned variable, totals, etc. Computing monthly financial scheduling, showing the columns that need not be changed every month of all projects of a company. In multi-project financial allocation, as per the priority of projects and criticality of activities, some re-allocation of budget between different heads and projects has to be made with joint meetings and exigencies of the situation.

6.4 Coal Projects Responsibility Scheduling

The main purpose is to ensure the achievement of targeted schedules, within budgeted cost and manpower, by solving day-to-day problems of responsibility scheduling [22,36]. Thus, a model program **'mbo'** is created, for a specific purpose, here for charting the key tasks for different management positions according to conditions in the coal mine project. Decision Chart and the query-based computer program can produce a revised Decision Chart, of any month for any project. On detail studies, the outcome of this process to standardize coal project 24 key tasks against 13 different management positions in the coal industry.

Job Effectiveness Description JED of a mine Project Manager, developed by the researcher, shows Program Run of mbo.java for a Particular Project for the Review Month. The executives in green-colored boxes should actively cooperate for the key task area shown, those in yellow color to help whenever required and those in red color need not bother for this key task and concentrate on their routine duties.

If the coal mine project officials are not responsive to the changing situations and stick to routine duties, the project would suffer and so there is a need for a responsibility schedule. Objective Setting by Action Plan, Responsibility scheduling with Decision Chart by Confidence Factor CF and sample run mbo.bat displays for a particular project for a certain month. Figure No-7 shows the flowchart executive manpower scheduling. Figure No-8 shows the model run of the program for different key tasks.

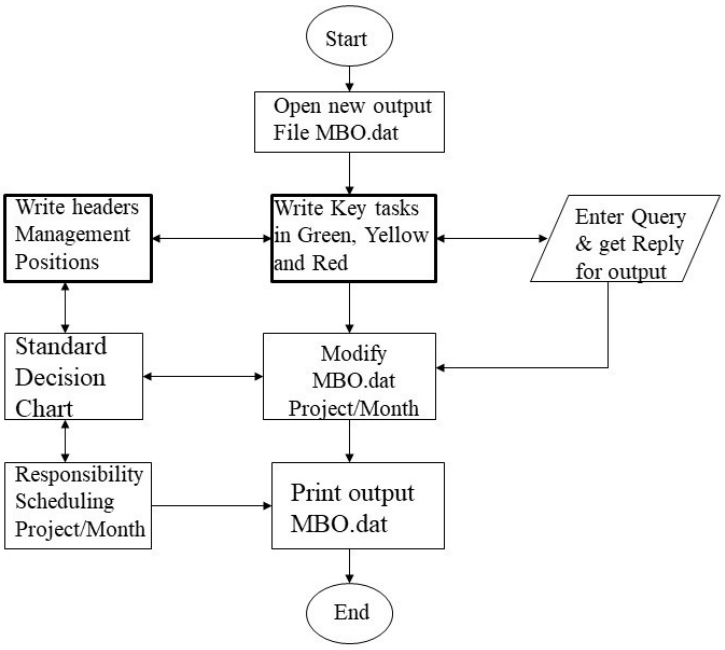

FIGURE NO- 7: FLOWCHART OF RESPONSIBILITY SCHEDULING

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FIGURE NO –8: RESPONSIBILITY SCHEDULING MBO.JAVA RUN

FOR A MONTH OF A PROJECT REVIEW – RED=Y, YELLOW=C, GREEN=N

6.5 Crisis Management

Quick scheduling of activities is very important in any disaster or crisis on [27]strategies with the allocation of responsibilities by phone, wireless, etc. Coal mining is very disaster-prone and numerous catastrophes have taken place owing to fire, explosion, inundation, roof-fall, etc. in which many employees lost their lives. Most of the equipment, skilled technicians, and executives for Mahabir rescue were by multi-project help.

Disaster struck at Mahabir Colliery, west of Raniganj town of ECL, a subsidiary of CIL on 13th Nov'89 at 4 AM, when there was a sudden inrush of water from old workings of upper Nega (R-VIII) seam to working Narainkuri (R-VII) seam. Water swirled down inundating the pit-bottom of the working pits A & B and lower workings of the mine. A program in COBOL was coded and run to find dewatering time. The program was later coded in Java dew.java for calculation of dewatering-time of a flooded mine.

In the model program, **'dew'** inputs of STAT_VOL (Static volume of water underground), SEPG_WAT (Make of water), DEW_RAT (Dewatering rate), FLB_RAT (into the mine through surface fissures), are made for computing DEW_TIME in days (for dewatering). A sample run of the model program, with incremental dewatering and flow-back rates of water, was done. Although 59 survivors were rescued on the 3rd day, ALT_NO 10 in the program run came close to reality, when after about a month, 6 dead bodies were recovered.

Disaster management scheduling, as accomplished, between 13/11/89 and 16/11/89, has been made on Openproj software. This is a unique world-record-making disaster management scheduling work, in which the researcher had played a key role. The researcher's contribution was acclaimed by international journals like Reader's Digest, June '91 issue in English, Oct '91 issue in Hindi, January'92 issue in Dutch, and many other language editions. Mahabir

capsule rescue is still a world record of its type, 65 employees in 4 days, in contrast to the rescue of the 33 miners trapped deep underground for 69 days, in a mine in Chile, who got trapped on 5 August and brought up on 14 October 2010.

6.6 Prioritization

Prioritization means identifying what is important and what is urgent, before deciding what to do next. Consider the Pareto principle, also known as the 80/20 rule; we get 80% of our results from 20% of our work. Prioritization should generate more time for the right things, for the valuable 20% which contributes to your long-term personal and professional goals. McKinsey survey: satisfied executives spent less time on administrative activities and more time making decisions, collaborating with their team, and engaging with stakeholders. There are several methods- Personal Prioritization Methods; Stephen Covey's Time-Management Matrix; Alan Lakein's ABC Method- A: High value, B: Medium value, C: Low value; Team Prioritization Methods; Stakeholder Prioritization Methods.

7. CONCLUSIONS

Research has taken help from application package developed by many organizations like CMPDI, for coal seam reserve estimation, ECL practical operations data, ISM, Dhanbad Decision Support System (DSS), CIMFR developed computer simulation packages. MOC, New Delhi office has been equipped with NIC COAL CELL and IP-based Video Conferencing System (EVCS).

The research has analyzed the results of hundreds of World Bank aided projects, indicating that success or failure often depends upon factors outside the control of the Project Manager. The management of projects has to depend upon many other external agencies, like Govt - Central & State, Contractors, suppliers, service engineers of equipment, etc. During the implementation of projects the following problems are faced during a review of monitoring and control: -

1. Master Control Network originally prepared by CMPDI, has to be revised for various reasons, delays, failures, etc.
2. It has also been experienced that due to escalation of prices of essential inputs as also change of activities, the sanctioned cost could not be adhered to and Revised Cost Estimates have to be made and sent for approval of Government.
3. Monitoring packages, sub-packages, and activity is not done properly at the project level normally, like start date, completion date, duration, resourced need, slippage, reasons for slippage, responsibility, physical and financial provision of critical activities required to overcome time and cost overrun.
4. Now, the computers supplied are updating of reports for feedback through Information System to reach right up to the ministry.
5. Computerized methods in model programs developed by the researcher can be very useful for the right planning, scheduling monitoring & prioritization of Indian coal mining projects.

Salient points should be beneficial for improving mining company performance: -

1) Environmental Impact Analysis (EIA) and the Environment Management Plan (EMP), can be now processed simultaneously instead of 2 stages and cleared in 16 months.

2) Forestry Clearance: The procedures are governed by the Forest (Conservation) Act 1980 and the Forest (Conservation) Rules 2003. The State Government has to process and forward it to the Central Government, for approval within 210 days. Mining companies have to show equivalent land for compensatory afforestation.
3) Compensation: In respect of any forest land to be released for coal mining, two monetary compensations are to be paid by the proponent: Net Present Value (NPV) and compensatory afforestation cost.
4) The computerized development of a database can help in financial resource planning for projects. Private companies allotted with many coal blocks can take advantage.
5) Coalmine projects require high investment and the world trend for high production mines for viability is noticeable.
6) Contractual agreements have assumed significant complexity, like the Client-Contractor agreement. Mixed-integer linear programming, based on practical methods can be applied.
7) Every Feasibility Report is recommended to have a Master Control Network, Project Management Service of the Subsidiary Company to update the network.
8) Quality assurance is required in contract services, discipline, change control, etc. Motivation is ensured by authority, influences, leadership, power, conflict resolution, team development, incentive, etc.
9) Proper monitoring is the key to a successful company, as it helps to determine the critical path, quicker completion of activities on it by crashing, reallocation of resources and minimize time overruns, which in turn also control cost overruns.
10) A system of equipment deployment with the equipment manufacturers/mine operators on a risk gain-sharing basis can be very useful for companies with large negative Net Worth, as no capital investment was required.
11) Both hardware and software compatibility is required between CIL and its subsidiaries so that any project network can be interfaced with COALNET intranet
12) Accurate EAC, or Estimate at Completion, is one of the most critical processes of projects. Estimate to Complete (ETC) - the cost of the work left to complete. So, EAC = Actuals + ETC.
13) The studies carried out should benefit the mining industry by applying the results in improving the performance of new and reorganized projects.
14) Our findings point to the importance of considering the long-run behavior of profits in the research that is at the intersection of entrepreneurship and regulation.
15) COALNET developed by MOC with the help of IIT, Kharagpur should be made more effective.
16) The hybrid Particle Swarm Optimization (HPSO) algorithm for multi-objective optimization is the latest trend.
17) The effectiveness of the use of navigation satellite systems (NSS) in the mining industry is reflected in many ways: in the renewal and replenishment of the topographic base for territorial objects of mining enterprises.

International Financial Reporting Standard (IFRS) is one of the accounting standards applicable internationally and has been used in different companies in different countries. Cost Auditors appointed by the Board of Directors for the financial year 2018-19 for Audit work of ECL have found that Net profit after tax attributable to Equity Share Holders (₹ in Crore) 931.17 about 126 million $. Net Worth increased to (₹ in crore) 1048.51 about 142 million $

from negative. These benefits show that the company has turned around from loss to profit and the research was successful.

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