# Cost Control & Optimization Technique for Sino Iron Project

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**Abstract.** Sino Project has to face to lots of uncontrollable factors from China and Australia which made the cost control be in an passive state as well as be exposed to great risks and difficulty since the commencement. How to effectively and efficiently control the project cost in the reasonable range is the engine to promote the whole project with smooth going. The answer is to monitor and control all kinds of consumption in scientific management to make sure that the project can be operated in lower cost compared with the similar projects in WA. In this paper, we try to research the cost control and optimization by Monte Carlo Method, PERT Network Optimization Technique and other solution to realize the project cost in delicacy management.

## Introduction

Since the project commenced, we have to deal with the large difference from the engineering construction environments between Australia and China, especially for limitation of construction subcontractor resource, higher manpower cost, lower work efficiency and longer construction period which made the project cost management and construction period control full of great risk and difficulty. Therefore, MCCM builds up a set of complete cost manage system to call up all of the members caring about the cost and deepening the process with layer-by-layer and precision solution as well as improving the cost control mechanism and disaggregating the cost index accompanied by tabbing the latent power, increasing speed and efficiency and optimizing structure to gradually form "*All members , Whole process and Full potential*" [1] cost control structure. In this paper, the true target to realize the cost control and optimization by Monte Carlo Method and PERT Network Technique is find the key points and route in the nominated cost control range to optimize the cost and realize the final cost control purpose.

## Project Cost Control and Optimization

**Sino Iron Project cost control by Monte Carlo Method.** To reach the cost control optimization, the project management team made decision to use Monte Carlo Method to manage, control and optimize cost control system as follows:

We firstly conduct random sampling for the duration of each activity in Project cost network to find the probable value which can meet with the duration distribution of the activity and take it as one duration value of this activity; then simulate the network planning cost schedule network based on the critical path to realize the long serials of items. Therefore, each simulation can provide one network planning cost schedule value for Cost Control Network through one nominated sample value in its probability distribution. By repeating the above simulation process, we can gradually get all sample values: $T_n$ to record the activity in the critical path of Sino Iron Project. We can use PC to statistic and compute the simulated results to obtain the mean value, variance and the activity critical of the project completion days.

The occurrence probability for one activity located in the critical path is also called its critical. There is at least one critical path from the initial node to the terminal node in all paths of Project Cost Schedule Network. The probability of one path turns to the critical one and the critical of the activity are respectively represented with "CR"and "CA" [2].

**Sino Iron Project control implement by PERT Network Technique.** The duration of each activity in PERT network technique should be the random variable met with different β distribution.

 

Firstly we estimate "*Three Time*" [3] for each activity, then obtain the mean value te and $V_{te}$ through estimated "*Three Time*" values:

At this time, it also need calculate β distribution parameter K1、K2 and β(K1,K2) of duration in each activity:

Another solution for K1、K2 is : let $A=\frac{4m+b-5a}{6(b-a)}$ ,Where, $k_1=6A$ , $k_2=6(1-A)$

Then, β(k1,k2) can be calculated by Complexification Two-point Gauss Integral:

$$\beta(k_1,k_2)=h\sum_{m=0}^{\frac{n}{2}-1}\{f[h(1-\tfrac{1}{\sqrt{3}}+2m)]+f[h(1+\tfrac{1}{\sqrt{3}}+2m)]\}$$

Where, n is complexification times (positive even number), While the truncation error≤10-5, we can let n＝12, $h=1/n$ $f(x)=x^{k_1-1}(1-x)^{k_2-1}$;

$$MF=\frac{(k_1-1)^{k_1-1}(k_2-1)^{k_{2-1}}}{\beta(k_1,k_2)(k_1+k_2-2)^{k_1+k_2-2}},\quad f(x)=\frac{1}{\beta(k_1,k_2)}x^{k_1-1}(1-x)^{k_2-1}$$

Then we conduct Rejection Technique random sampling to produce the activity duration according with β distribution.

Repeat the above-mentioned sampling processes; we can obtain one set of sampling values for activity duration: t, which should meet with its β distribution (corresponding with applied MF value and f(x)). Keeping on the random sampling, it will produce N samplings met with its β distribution.

Selecting the first set of random sampling duration values for each activity, we can computer for CPM time parameter and obtain the first sampling value $T_{n-1}$ in the network planning cost schedule, then we can find out the cost critical schedule as well as record finishing the first simulation for the activity in the critical path; selecting the second set of random sampling duration values for each activity, we also can computer and obtain the first sampling value $T_{n-2}$, as well as record it. Gradually repeating the above-mentioned processes, we also can first sampling value $T_{n-N}$ from the $N_{th}$ (also the last one) set of random sampling duration values for each activity and record it as the last simulation. If all basic data are true as well as enough large for sampling, the simulated mean value and variance will unlimitedly approach to the true value in any precision.

**Cost Optimization.** The practical experience has clearly shown that the cost optimization is closely bound up with construction period cost at the beginning. That is, to realize the cost optimization, you have to find out the reasonable construction period schedule under the lowest project total cost, or search for the lowest planning schedule based on the fixed construction period.

Incidence relation between Cost and Time

Sino project total construction cost mainly includes: Direct Cost (manpower cost, material cost, machine and plant cost, other direct cost and on-site cost, etc.), Indirect Cost(all cost spent in the project operation and management) [4] as well as other profit and loss (increment benefit and time value of money) caused by construction period change. Their interrelation and trend between Total Cost, Direct Cost and Indirect Cost and construction period are clearly reflected in Fig. 1:

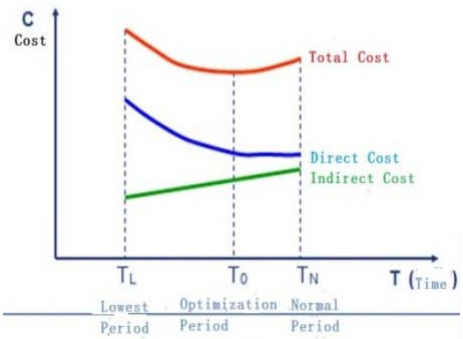


Fig. 1

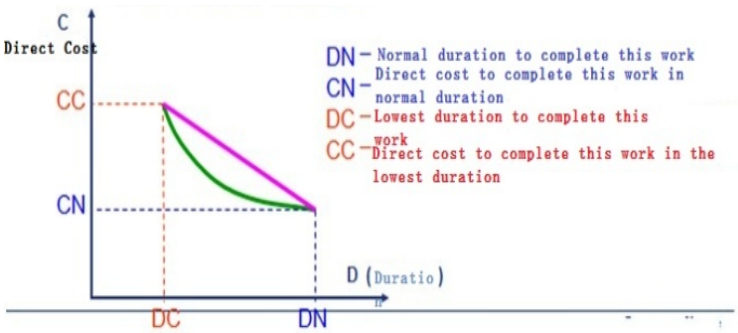


Fig. 2

The optimization mainly follows up the specialties of the direct cost from the critical work, namely, it is one increasing curved line while shortening duration. Furthermore, if the work division is not rough, it also can meet with the precision requirements while it is simplified to one straight line shown in Fig.2.

Here, the direct cost ratio is the increased direct cost per unit interval shortened from work

duration with the formula: $\Delta C_{i-j} = \frac{CC_{i-j} - CN_{i-j}}{DN_{i-j} - DC_{i-j}}$

While compressing several critical work in several critical paths, the group with the minimum sum of their direct cost ratios is usually the priority compressed one.

Cost optimization method for Sino Iron Project

Based on Sino Iron Project is a large-scale, long-term construction period, higher construction difficulty, complex working procedure, and huge cross-operation project, we set out the following cost optimization methods:

Gradually find out critical work with minimum direct cost ratio (or combined direct cost ratio) from the network planning cost schedule; shorten its duration little by little as well as consider the decreased indirect cost value at the same time; finally obtain the reasonable construction schedule arrangement at the minimum project total cost or the lowest cost schedule arrangement at the required project duration. Its detail optimization steps as follows:

Determine the calculated construction period and critical path based on normal work duration;

Calculate the direct cost ratio for each work;

Select and analyze the critical path based on the direct cost ratios, and choose the critical work with minimum direct cost ratio of critical works with minimum combined direct cost ratio;

Select the compressibility for the critical work or works, gradually compare the direct cost ratio with indirect cost ratio: compressing the duration until the direct cost ratio is bigger than indirect cost ratio.Then go to Step g;

Compress its duration till the final duration for compressed critical work no less than its minimum duration but it should still be critical work;

Obtain the calculated construction period after compressing duration of the selected work as well as the critical path and corresponding increased total cost: If the calculated period can meet with the required construction period, go to Step g;

Repeat Step c～f

Calculate the optimized project total cost.

Through this whole flow chat, the cost and duration are compressed and optimized gradually so as to obtain the ideal optimization result of work total cost. This cost optimization method had been tested in some unit works in Sino Iron Project.

Cost optimization sample in Sino Iron Project

During set out the optimization flow-chat for the ore stockpile( Unit Work) in the Concentrate Area of Sino Iron Project, the four numbers respectively located out of and in the bracket below and above the arrow line represent work normal duration, minimum duration, and work direct cost (Unit: ten thousand USD) completed in normal duration and in minimum duration shown in Fig.3 The indirect cost for this unit work is 8000USD.

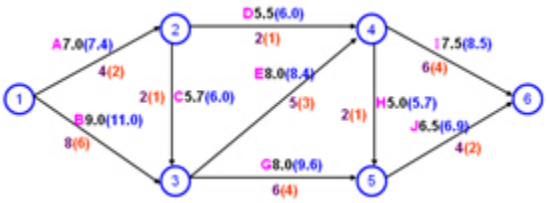


Fig. 3

Use labeling method to determine calculated period and critical path based on normal duration for each work: calculated period: 19days and two critical paths: ① →③ →④ →⑥ and ① →③ →④ →⑤ →⑥

Calculate direct cost ratio for each work:

$$\Delta C_{2-3} = \frac{CC_{2-3} - CN_{2-3}}{DN_{2-3} - DC_{2-3}} = \frac{6.0-5.7}{2-1} \qquad \Delta C_{1-3} = \frac{CC_{1-3} - CN_{1-3}}{DN_{1-3} - DC_{1-3}} = \frac{11.0-9.0}{8-6}; \qquad \Delta C_{3-4} = \frac{CC_{3-4} - CN_{3-4}}{DN_{3-4} - DC_{3-4}} = \frac{8.4-8.0}{5-3};$$

$$\Delta C_{2-4} = \frac{CC_{2-4} - CN_{2-4}}{DN_{2-4} - DC_{2-4}} = \frac{6.0-5.5}{2-1} \qquad \Delta C_{1-2} = \frac{CC_{1-2} - CN_{1-2}}{DN_{1-2} - DC_{1-2}} = \frac{7.4-7.0}{4-2} \qquad \Delta C_{5-6} = \frac{CC_{5-6} - CN_{5-6}}{DN_{5-6} - DC_{5-6}} = \frac{6.9-6.5}{4-2};$$

$$\Delta C_{4-6} = \frac{CC_{4-6} - CN_{4-6}}{DN_{4-6} - DC_{4-6}} = \frac{8.5-7.5}{6-4}; \quad \Delta C_{4-5} = \frac{CC_{4-5} - CN_{4-5}}{DN_{4-5} - DC_{4-5}} = \frac{5.7-5.0}{2-1} \quad \Delta C_{3-5} = \frac{CC_{3-5} - CN_{3-5}}{DN_{3-5} - DC_{3-5}} = \frac{9.6-8.0}{6-4};$$

Calculate the total cost for this unit work:

Direct Cost:$C_d$=622000USD, Indirect Cost：$C_i$=152000USD, Total Cost: $C_t$=$C_d$+$C_i$==774000USD

After compressing the corresponding critical work and duration, we can re-calculate the optimized total cost:

$C_{d0}$=635000USD, $C_{i0}$=128000USD, C: $C_{t0}$= $C_{d0}$+$C_{i0}$=763600USD.

After strictly conducting the limited conditions, we can save 2~10% of the total cost than the similar work without optimization. Obviously, it can act very critical function in the project total cost control, and be worth of promoting in the future project.

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