DAILY SITE INTERPRETATION TOOLS FOR DIFFERENT HIERACHICAL LEVELS IN A CONSTRUCTION PROJECT

by

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We accept this thesis as conforming
to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA

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Department of CIVIL ENGINEERING

The University of British Columbia
Vancouver, Canada

Date 28th January, 1994

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ABSTRACT

This thesis is an extension of Fayek's work (Fayek 1992) on the automated interpretation of a construction activity's problems and suggestion of possible corrective actions. It consists of three major parts.

First, an extensive field test was undertaken in order to obtain a real data set to test and validate both Fayek's work and extensions to it. As part of this exercise, an attempt was made to capture the expertise of seasoned construction personnel regarding the selection of corrective actions as a function of problem source and prevailing job site conditions. The original problem source list was extended from seven problem sources to fifteen, and corrective actions for the new sources were identified.

The second part of the thesis, which constitutes the core of the work, deals with the formulation of a general, higher-level analysis schema. It includes integrating across all problem sources and corrective actions at the activity level, and the detection of patterns of problems at the trade and overall project levels, along with the suggestion of higher-level corrective actions. One of the challenges confronted in this work is the need to deal with conflicting corrective actions arising from the diagnosis. Several examples are given to illustrate the workings of a prototype.

Lastly, the graphical representation of daily site data is partially explored. Construction personnel are often overwhelmed by the amount of data that describes a project. The use of graphics, especially the stacking of different graphs, helps the user to identify patterns of problems and provides insights into causation. Various graphical images are presented, along with suggestions for more complex three-dimensional representations.

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I wish to express my sincere appreciation to my advisor Professor A. D. Russell, whose inputs, encouragement, inspiration and other qualities of excellence have contributed a great deal over the years. A special thanks goes to John Scott, John Mills, and Bill Jaeggle of J.C. Scott Construction Ltd. for their cooperation, willingness, and patience during the field study. Finally, I thank my family for their patience, understanding, and encouragement while the thesis was being written.

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CHAPTER 1.0 INTRODUCTION

1.1 FOCUS OF THE THESIS

This thesis is an extension of Fayek's work (Fayek 1992) on the automated interpretation of a construction activity's problems and suggestion of possible corrective actions. It consists of three major parts.

First, an extensive field test was undertaken in order to obtain a real data set to test and validate both Fayek's work and extensions to it. As part of this exercise, an attempt was made to capture the expertise of seasoned construction personnel regarding the selection of corrective actions as a function of problem source and prevailing job site conditions. The original problem source list was extended from seven problem sources to fifteen, and corrective actions for the new sources were identified.

The second part of the thesis, which constitutes the core of the work, is the formulation of higher-level analysis schema. These include integrating across all problem sources and corrective actions at the activity level, and the detection of patterns of problems at the trade and overall project levels, along with the suggestion of higher-level corrective actions. One of the challenges confronted in this work is the need to deal with conflicting corrective actions arising from the diagnosis. Different reasoning schema and approaches presented in the literature are explored and compared with the reasoning approach adopted.

Lastly, the graphical representation of daily site data is partially explored. Construction personnel are often overwhelmed by the amount of data that describes a project. The use of graphics,

especially the stacking of different graphs, helps the user to identify patterns of problems and provides insights into causation. Various graphical images are presented, along with suggestions for more complex three-dimensional representations.

1.2 THESIS STRUCTURE

Chapter 1 describes the goals and structure of the thesis. The prototype framework of the data interpretation and analysis system for individual problem sources as developed by Fayek (1992) is described. This framework provides the starting point for the work described herein.

Chapter 2 describes the field study performed. The method of data collection, the description of the project, the type of data collected, and the acceptability and usefulness of the data collected are treated. The usefulness of various graphical representations of the daily site data is explored, and suggestions are made for further graphics work.

Chapter 3 sets out the analysis schema devised for second and higher level analysis. Several additions to the existing system, including derivation of trade attributes as a function of activity attributes and formulation of a dispersion index, are described.

Testing and the validation of the extended interpretation system is described in Chapter 4.

Chapter 5 summarizes the thesis in the form of conclusions and gives recommendations for future work.

1.3 OVERVIEW OF FAYEK REASONING SYSTEM

Since the work of Fayek (1992) provides the starting point, an overview of the approach adopted along with a definition of symbols is given. It is noted that other reasoning approaches could be examined (and should be in the longer term). However, the system as originally developed shows promise and its potential should be fully explored, including several needed extensions before other reasoning schema are tackled.

The basic building blocks of Fayek's system consist of: project-wide data in the form of weather conditions, site conditions, and work force data; system-derived and user-assigned activity attributes; problem sources and their time (days lost) and cost (man-hours lost) impacts; types of problems (time, cost, quality); and corrective actions. In addition, an expert rule base, combined with a fuzzy logic framework, is used to link the various building blocks together. This framework makes use of two analysis schema: one to link problem sources to corrective actions based on user-assigned activity interpretation attributes (Schema A); the other to link problem sources to corrective actions based on the type of problem arising out of the problem source (Schema B).

In Schema A, S_{ja} is the strength of the linkage between a problem source, X_j, and a user-assigned activity interpretation attribute, V_a. It is the product of the degree of applicability, D_{ai}, to activity i, of attribute V_a by the user-assigned standard strength, B_{ja}, between problem source X_j and attribute V_a. Matrix S(X, V) is composed of elements S_{ja}. $T_{ja,c}$ is the strength of the linkage between an interpretation attribute and a corrective action, Z_c for a problem source, as determined by a set of expert rules. Matrix T(V,Z) is composed of elements $T_{ja,c}$. A fuzzy composition operation (max-min or cum-min) is used to determine the relationship between the set of problem sources, X, and the set of corrective actions, Z, through their respective relationships to the set of interpretation attributes, V,

to yield a matrix R1(X,Z).

In Schema B, P_{jd} is the strength of the linkage between a problem source, X_j, and a problem type, Y_d, as determined by a set of expert rules that account for the attributes of the problem source (days and man-hours lost) and the type of problem source. Matrix P(X,Y) is composed of elements P_{jd}. $Q_{jd,c}$ is the strength of the linkage between a problem type and a corrective action, Z_c, for a problem source, as determined by a set of expert rules. Matrix Q(Y,Z) is composed of element $Q_{jd,c}$. A fuzzy composition operation (man-min or cum-min) is used to determine the relationship between the set of problem sources, X, and the set of corrective actions, Z, through their respective relationships to the set of interpretation attributes, Y, to yield a matrix R2(X,Z). Analysis schema A and B are combined using an intersection operation to produce a matrix R(X,Z). The elements of this matrix are the strengths with which corrective actions, Z, are recommended for problem sources, X.

The purpose of suggesting corrective actions based on two sets of data (activity attributes and problem types) is to make use of supporting evidence from all sources as a form of corroborating information to suggest the most suitable corrective action(s). It is possible to suggest corrective actions based solely on reported problem sources. Accounting for the activity's attributes provides refinement to these suggestions. Accounting for the type(s) of problem(s) resulting also provides refinement. Taking both the attributes and the problem type(s) into account yields a set of corrective actions that are recommended most strongly if both sets of data point to them. Thus, the greater the amount of supporting evidence pointing to a corrective action, the more highly it is recommended.

Fayek demonstrated the practicality of the prototype system. However, it was deficient in several respects. The diagnosis is conducted on a problem source by problem source basis for each

activity, and the results of the analysis, including suggested corrective actions, are output to the user, regardless of what corrective actions may have been initiated previously. Although suggested for further work, no attempt was made to merge corrective actions for all problem sources for a given activity, and no analysis was conducted to look for patterns of problems across activities at both the trade and overall project levels.

What is needed is a weighing scheme to combine all of the sets of corrective actions for each problem source into one set in such a way that conflicts are minimized. Given the recommended corrective actions for each problem source for each activity, a number of criteria and procedures could be used to combine them. Weighing factors could be derived based upon one of the frequency of problem sources, the magnitude of time-lost or the magnitude of man-hours lost. In some cases, this means that the number of elements in the combined set will be less than the union of the individual sets. These corrective actions, along with the problem sources they address, should then be stored for further analysis at the trade and overall project levels.

Different sets of corrective actions and expert rules' bases are required for the higher levels of analysis. In order to fully assess the impacts of problems occurring on a particular project, the analysis should be performed at each of these levels and corrective actions suggested at each tier. Moreover, a schema in recording recommendations from previous analyses is needed.

CHAPTER 2.0 FIELD STUDY AND GRAPHICS REPRESENTATION OF DATA

2.1 OBJECTIVES

The objectives for the field study were several-fold:

1. To let experts in industry review the problem sources, the corrective action list and expert rules linking problem sources with corrective actions.

2. To obtain a comprehensive time history of an ongoing project in the form of a daily site data set for system validation and calibration purposes. The goal here was to have an impartial observer collect the data set so that it is as objective and as complete as possible. The potential exists for site personnel to be biased and/or selective in the recording of information and attribution of problems.

3. To extend the current list of problem sources to treat commonly occurring ones.

4. To identify additional corrective actions which are consistent with the extended problem source list and review existing corrective actions with seasoned project management personnel.

2.2 DESCRIPTION OF THE PROJECT AND AUTHOR'S ROLE

2.2.1 PHYSICAL FEATURES OF THE PROJECT

The project studied was a six-story, reinforced concrete, 100 bed, extended medical care facility at 3490 Porter Street, Vancouver, B.C.. The total cost of construction was approximately $4.0 million. J.C. Scott Construction Limited (JSC) of Vancouver was the construction manager.

The building itself is divided into north and south wings. A wall between the wings separates the building to obtain a two-zone fire rating. The basement of the building contains kitchen, laundry and parking facilities. The main floor houses the lobby and offices in the north wing and patient rooms in the south wing. Levels two to five are typical floors for patient rooms. The sixth floor contains a large dining area and offices. Overall, the building is similar to a hospital except that it does not have any oxygen supply service.

The physical site was an irregular lot located at the corner of Victoria Drive, Commercial Drive and Porter Street, forming the east, south and west boundaries of the site, respectively. Victoria Drive and Commercial Drive are both busy routes in Vancouver. Thus, there were problems for external access to the site for loading/unloading. A special zoning was granted by the City on Victoria Drive adjacent to the site to temporarily disallow public parking during business hours. In addition, traffic flagmen were needed for large/lengthy deliveries, e.g. concrete delivery for floor slabs. Only a limited amount of delivery could be done at a time. Once in a while, delivery vehicles had to wait in a queue or return at a later time.

During the removal of the crane, a special one day permit was issued to transform Victoria Drive into single lane traffic. This further limited the delivery to the site on that day. The construction manager arranged with the trades to make sure that the suppliers had delivered all the major materials and equipment needed to complete the project before the crane's removal. A week before the removal of crane, time usage for the crane was scheduled in half-hour increments to complete loading of the building. After the crane's removal, forklifts and mobile cranes were used on an intermittent basis to place materials and equipment.

The elevated guideway for Skytrain (ALRT system in Vancouver) ran alongside the southwestern boundary of the project. This imposed limits on the location and usage of the crane. After much consideration, the crane was purposely set up on the Skytrain side of the boundary, ten feet from the rail structure. The reason for doing this was to prevent the tip of the crane from swinging across the rail. Doing so would cause an emergency alarm in the crane to ring and could result in the total shut down of the crane by Skytrain officials.

Because of this position of the crane, the crane operator was unable to see the delivery area when the building height reached the 5th floor. Management had not envisaged the need to place an extra control room at the tip of the crane. Thus, a concrete pump was used to place the sixth floor slab and the roof, resulting in extra cost.

When forming the floor slab for the 4th floor of the building, the structure itself reached the level of the rail. Vandals who entered the site illegally could therefore use the building to get onto the guideway. Thus, special meetings were conducted between Skytrain officials and JSC. To resolve this situation, plywood sheets were used to cover the crane's column truss structure. It was done so that intruders who went onto the site could not use the crane as a step to the guideway structure. Moreover, when it was time to form, pour and strip the stairwell on the Skytrain side of the building, personnel from the ALRT control system visited the site to ensure that no formwork or concrete would fall onto the tracks.

During the drywall and exterior enclosure phase of the building, a tough 1" plastic mesh was placed outside the scaffolding along the ALRT side of the building. The mesh was placed to prevent any waste material from falling onto the track.

2.2.2 ROLE OF J.C. SCOTT CONSTRUCTION LTD.

J.C. Scott Construction Ltd. was the construction manager for the project. The company is a young, aggressive firm in Vancouver which specializes in construction management for high-rise residential buildings. For planning and scheduling, the company uses a commercial version of the REPCON construction management program plus a Daily Site Reporting system which has been developed under a research program sponsored by J.C. Scott Construction Ltd. and W. A. Stephenson Construction Ltd.. This system is fully integrated with REPCON. REPCON was originally developed as part of an extended research program at UBC under the direction of Professor A. D. Russell.

For this project, JCS represented the owner and managed the construction aspects of the project. The majority of the work for this project was subcontracted out to different trades. Monitoring the site directly, JCS coordinated all information amongst the trades and the design consultants. Information from the consultants was first passed onto the project manager and then sent to the appropriate sub-trades. Inspections such as building inspection, energy-efficiency inspection, concrete testing, etc., were arranged by JCS to ensure that the building complied with all legal requirements and restrictions.

JCS assigned one project manager, one superintendent, one construction safety officer and one foreman to the project for its entire duration. Occasionally, labourers and other carpenters were called in for miscellaneous activities, e.g. installing window sills and hardware backing.

2.2.3 MANAGEMENT PROCEDURES

Management procedures used are described below under the subheadings of communication channels, personality of key management personnel, and contractor information practices.

Communication Channels

The project manager acted as a bridge between the consultants and the trades. Information requested, clarifications, and errors were sent to the appropriate consultants to ensure constructibility of the project. Changes, clarifications and revisions from consultants were distributed to the relevant sub-trades. If the current situation could not be described clearly through sketches and telephone conversations, the consultants were asked to come to the site to resolve the problem.

When a sub-trade encountered a problem, the superintendent and the foreman were to be notified first about the problem. The superintendent would then try to resolve the problem or conflicts on site or call upon the appropriate consultants for additional information/clarifications. He would also summarize problems at the site to the project manager at the end of each working day. If he was not successful in solving a problem, he would pass the relevant information on to the project manager and ask if he could resolve the situation. The project manager would then take over the problem and would deal with the trade and/or consultant himself.

Every Tuesday morning a trade meeting was held at the site to effect information flow and coordination amongst the trades. The meeting was conducted by the project manager, and each trade in progress was asked to send a representative to attend. During the meeting, progress of the trades was summarized and their performance was evaluated. Any problems encountered were reported and their solutions were looked for when problems could not be resolved immediately amongst the trades. Information requested for and from consultants was noted. Each meeting ranged between 30 minutes to 1 hour in duration.

Similar meetings were held at the site between the various consultants (architect and engineers).

These meetings were held initially once a month, and later became biweekly meetings at the request of the project manager. The architect chaired the meeting. The main purpose of these meetings was to improve coordination amongst the consultants and to resolve design conflicts by viewing the situation directly on site. Information and clarifications requested by subcontractors were presented in the meetings to make sure that they were addressed.

Personalities of management team key personnel

Since different experts confront problems different ways, it is of interest to point out the personalities of the different construction experts involved in this project. During the study period, the project managers changed. The two project managers had very different approaches to site management.

The first project manager tended to reason with the sub-trades and worked with them as a team. This made him more forgiving of trade mistakes. He would allow the trades to use extra time to recover their mistake as long as the total schedule was not delayed. He tried to be their friends and believed that if he was lenient then the trades would be more responsive. Overall, he sought to maintain harmony in the working environment.

This first manager used REPCON to schedule the project, although he did not use the program to its and his best advantage. The original project plan and schedule was done in a very cursory manner which did not facilitate effective daily site reporting and schedule updating from the daily site data base. Also, the schedule was not particularly aggressive--for example, no intermediate floors were sealed off to let drywalling start as early as possible. Moreover, he did not update the project schedule to reflect progress of on-going activities. He believed that a planning and scheduling system is just a tool to help

him get familiar with the project, and one should never be too deeply dependent on such a system. He was not conversant with the REPCON scheduling system. As part of this research project, a special training session was held for him to get accustomed to it. As the project unfolded under the direction of this project manager, it fell further and further behind the anticipated spring delivery date. When an update of the schedule indicated a fall completion, the first project manager was effectively fired.

The second project manager was a much more aggressive person. He would not tolerate any delay in a trade's performance. If a trade was delayed or a mistake was made, he would then ask the trade to speed up and correct the problem. He documented everything and would threaten back-charging and other legal actions if corrective actions were not initiated. In addition, as soon as any activity finished, he wanted its successor activities to commence. His goal was to have every activity start in accordance with an early start date. He sought considerable detail in the plan and scheduled, and hence it was extensively modified, with many activities added. Strategies such as sealing off floors to permit early start of drywall activities were adopted. The schedule was ultimately brought back in line with the required spring completion.

This project manager, while a user of REPCON reports, was not familiar with the operation of the program; however, he is a strong believer in computerized project scheduling. He himself used a matrix schedule, i.e., a chart with activities on the y-axis, activity locations on the x-axis and the starting date in each cell, which was generated by a spreadsheet program using output from the planning and scheduling system. Project performance was closely monitored against the matrix schedule. Interestingly, REPCON can produce a matrix schedule with activities on the x-axis and locations on the y-axis. The project manager insisted that the results be transposed, hence the use of a spreadsheet.

The superintendent was a very experienced field person who had been in construction for many years and had worked for JCS for over 7 years. He had encountered many different construction problems during his career. He worked well with the trades, and often he was able to solve their problems directly on site. Frequently, design errors and conflicts were detected by him before the work started on an activity. Moreover, with his experience, he could easily detect whether the trades had real problems or were just playing games to try to get more time.

Contractor Information Practices

As noted previously, JCS uses the commercial version of REPCON plus an earlier version of the daily site reporting research system. Updating with the daily site reporting system becomes much easier and can be conducted more frequently. The system shows whether activities are progressing in an unacceptable manner or not. More creditability is given to the schedule since the decision maker has a more current representation of the project. For example, the superintendent frequently utilized the daily site report to determine the performance of the forming subcontractor. He then used the daily site report to calculate the total man-hours of the crew, the percent of work completed, the cost-to-date, and the performance index (input/output) of the trade. Overall, this provided him with the ability to control different subtrades and pinpoint any problem sources for on-going activities.

A new set of daily site reports was generated biweekly from the office. At the end of each working day, the superintendent completed that day's daily site report. It was then sent back to the office and the relevant data entered into the computer by a person in office. The schedule could then be updated to reflect progress in the field (although the frequency of updating was low and there was a considerable backlog of data entry).

2.2.4 ROLE OF AUTHOR

A data set was obtained through a six month internship by the author from July 1992 to January 1993 using the research version of REPCON which included Fayek's prototype system. The data structures for the commercial and research versions are different, and hence the project files were not compatible. The original plan and schedule of the project designed by the first project manager was recreated using the research system and then refined with more details. This revised plan and schedule was further refined as the project progressed, and was reworked extensively when project managers changed. The schedule in bar-chart form, as of 14th January, 1993, is shown in Figure 2.1.

Acting as an observer, I recorded the progress for on-going activities using the daily site system at the end of each working day. The report (see Figure 2.2 for a typical format) recorded information dealing with weather data, work force data, tests and inspections, equipment rentals, materials delivered, activity status, problem sources and consequences, etc.. If a problem occurred in an activity, the corresponding problem sources were selected by the user and description(s) of the problem(s) entered. The estimated amount of time lost and/or man-hours lost was noted down in the daily site report (see section 2.3).

Other duties of the author consisted of creating detailed schedules, e.g. drywall and finishing schedules, establishing a room numbering routine and layout for the consultants, contracting for the fire-proofing trade, reporting delays in activities to the project manager and superintendent, helping with general layout of the floors, and so forth.

Decisions taken to rectify different problems were noted. Often, the project manager revised the schedule sequence to reflect changes in the construction strategy. For example, when constructing the

floor slab, due to the considerable amount of mechanical and electrical equipment to be placed on certain slabs, the rebar crew deliberately started from the other end of the building for those slabs to allow the mechanical and electrical crews enough time to rough-in their equipment. These changes were noted in the Daily Site Report.

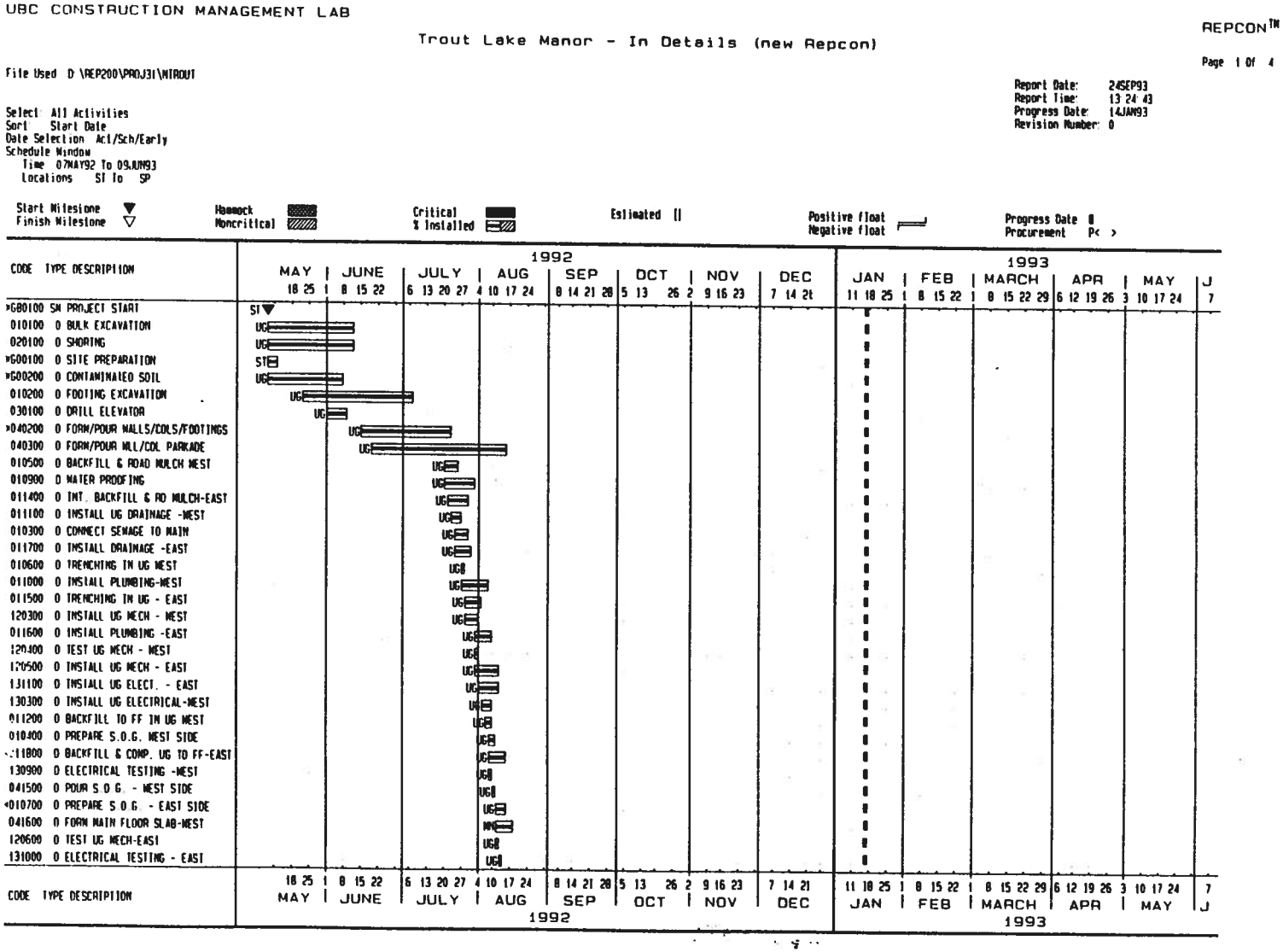
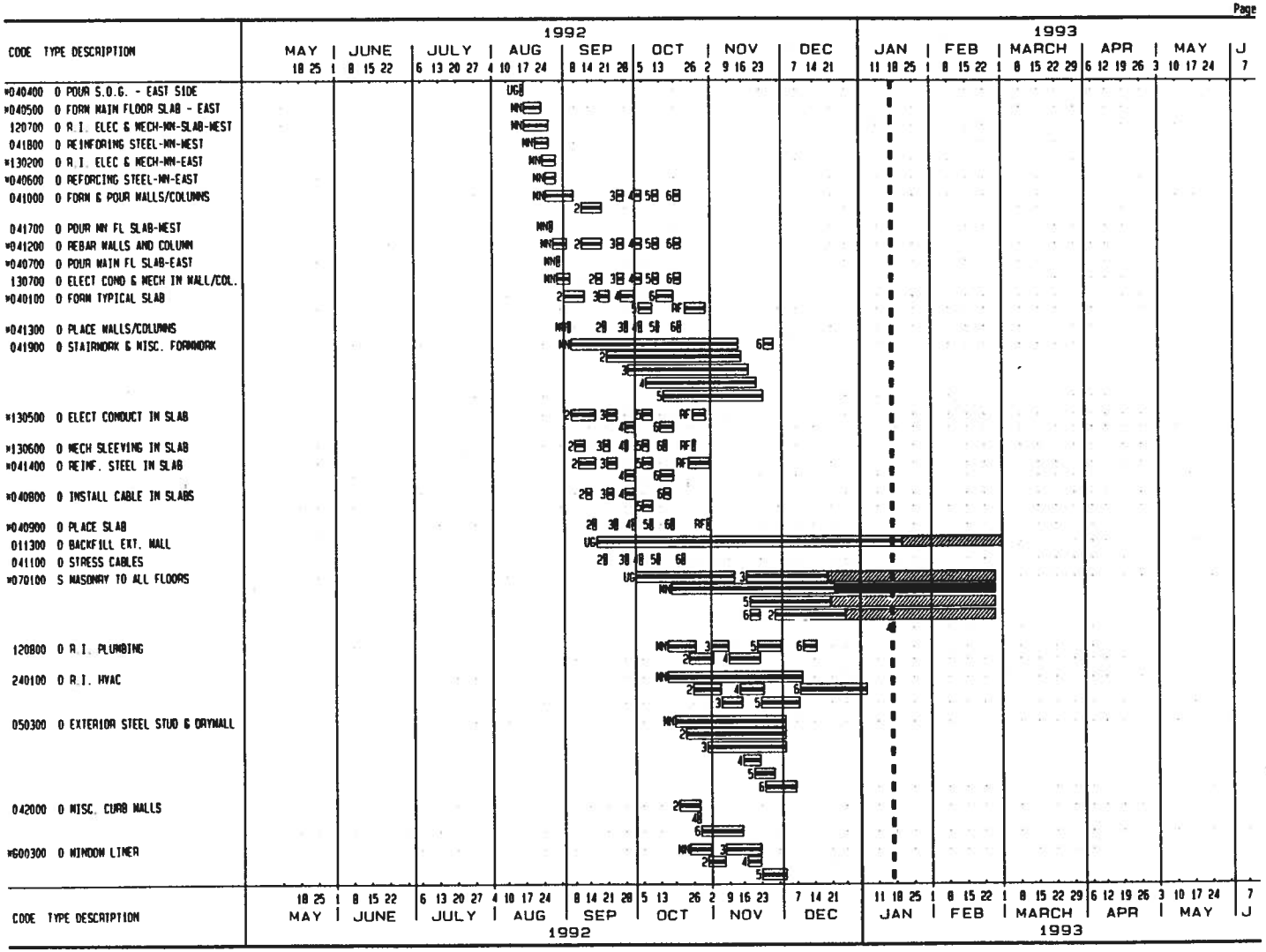
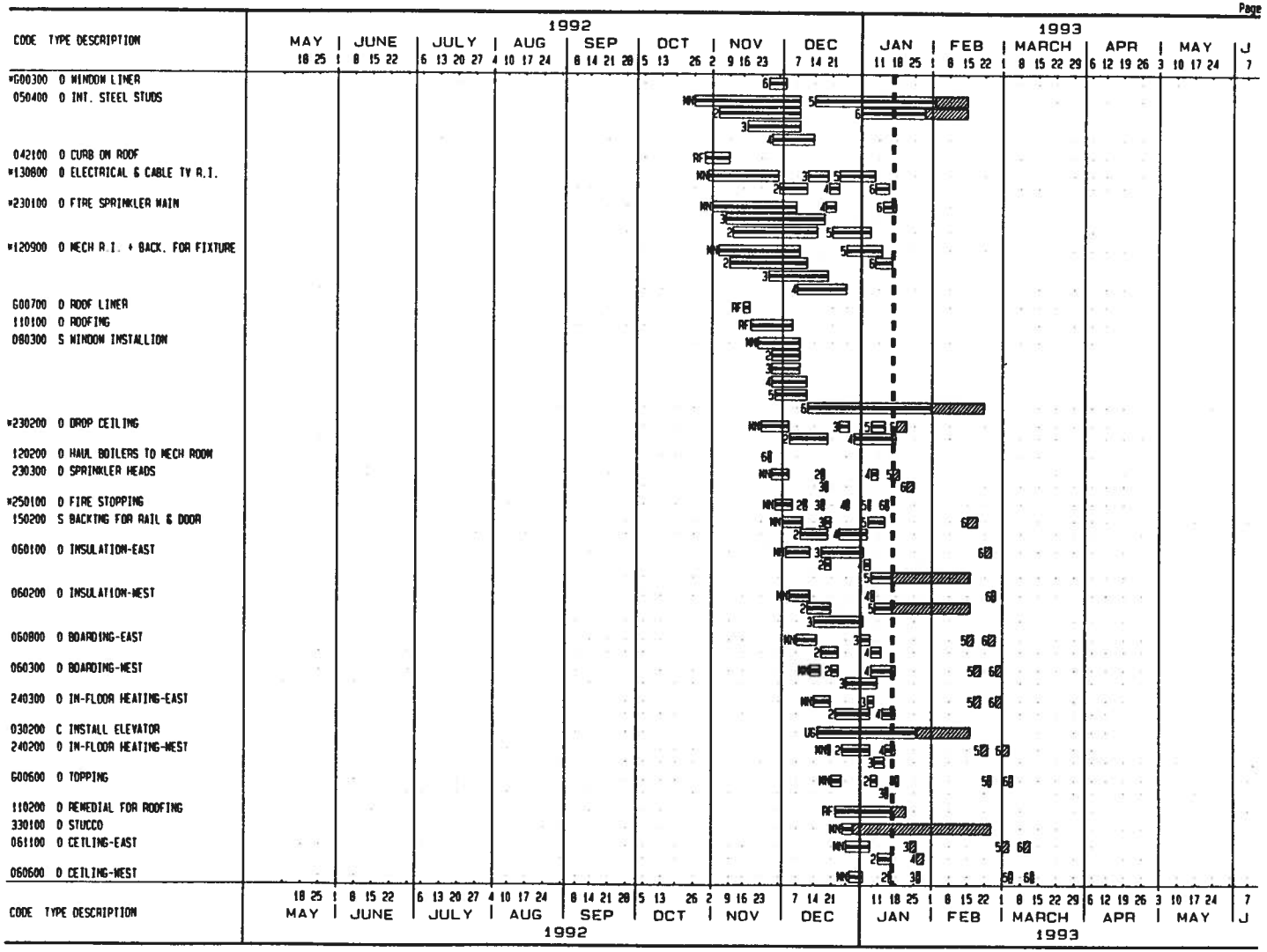
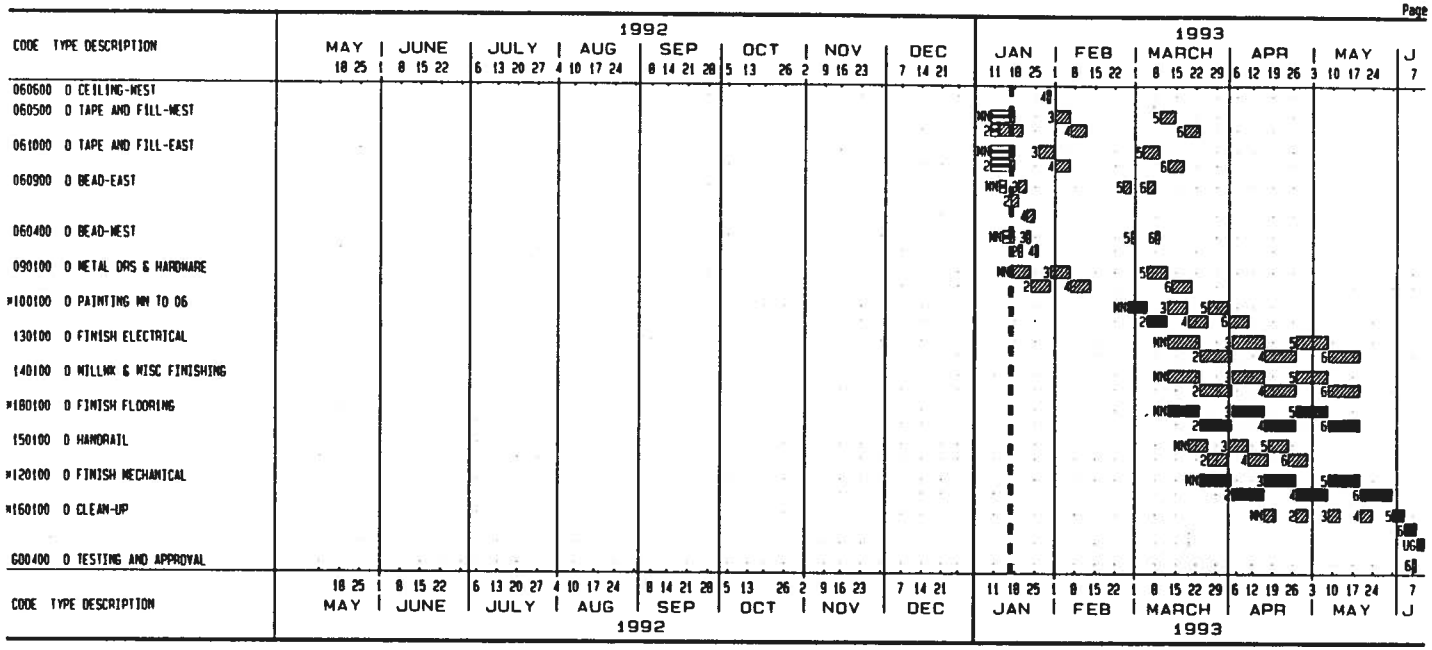


Fig. 2.1 Project schedule in bar chart format


1992
1993
MAY
JUNE
JULY
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MARCH
APR
MAY
J
CODE TYPE DESCRIPTION
*040400 O POUR S.O.G. - EAST SIDE
*040500 O FORM MAIN FLOOR SLAB - EAST
120700 O R.I. ELEC & MECH-NN-SLAB-WEST
041800 O REINFORING STEEL-NN-WEST
*130200 O R.I. ELEC & MECH-NN-EAST
*040600 O REFORCING STEEL-NN-EAST
041000 O FORM & POUR WALLS/COLUMNS
041700 O POUR NN FL SLAB-WEST
*041200 O REBAR WALLS AND COLUMN
*040700 O POUR MAIN FL SLAB-EAST
130700 O ELECT COND & MECH IN WALL/COL.
*040100 O FORM TYPICAL SLAB
*041300 O PLACE WALLS/COLUMNS
041900 O STAIRWORK & MISC. FORMWORK
*130500 O ELECT CONDUCT IN SLAB
*130600 O MECH SLEEVING IN SLAB
*041400 O REINF. STEEL IN SLAB
*040800 O INSTALL CABLE IN SLABS
*040900 O PLACE SLAB
011300 O BACKFILL EXT. WALL
041100 O STRESS CABLES
*070100 S MASONRY TO ALL FLOORS
120800 O R.I. PLUMBING
240100 O R.I. HVAC
050300 O EXTERIOR STEEL STUD & DRYWALL
042000 O MISC. CURB WALLS
*600300 O WINDOW LINER


1992
1993
CODE TYPE DESCRIPTION
MAY
JUNE
JULY
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MARCH
APR
MAY
J
*G00300 O WINDOW LINER
050400 O INT. STEEL STUDS
042100 O CURB ON ROOF
*130800 O ELECTRICAL & CABLE TV R.I.
*230100 O FIRE SPRINKLER MAIN
*120900 O MECH R.I. + BACK. FOR FIXTURE
G00700 O ROOF LINER
110100 O ROOFING
080300 S WINDOW INSTALLION
*230200 O DROP CEILING
120200 O HAUL BOILERS TO MECH ROOM
230300 O SPRINKLER HEADS
*250100 O FIRE STOPPING
150200 S BACKING FOR RAIL & DOOR
060100 O INSULATION-EAST
060200 O INSULATION-WEST
060800 O BOARDING-EAST
060300 O BOARDING-WEST
240300 O IN-FLOOR HEATING-EAST
030200 C INSTALL ELEVATOR
240200 O IN-FLOOR HEATING-WEST
G00600 O TOPPING
110200 O REMEDIAL FOR ROOFING
330100 O STUCCO
061100 O CEILING-EAST
060600 O CEILING-WEST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1992
MAY 18 25
JUNE 1 8 15 22
JULY 6 13 20 27
AUG 4 10 17 24
SEP 31 8 14 21 28
OCT 5 13 26
NOV 2 9 16 23
DEC 7 14 21
1993
JAN 11 18 25
FEB 1 8 15 22
MARCH 1 8 15 22 29
APR 5 12 19 26
MAY 3 10 17 24
J 7
060600 0 CEILING-WEST
060500 0 TAPE AND FILL-WEST
061000 0 TAPE AND FILL-EAST
060900 0 BEAD-EAST
060400 0 BEAD-WEST
090100 0 METAL DRS & HARDWARE
*100100 0 PAINTING MH TO 06
130100 0 FINISH ELECTRICAL
140100 0 MILLWK & MISC FINISHING
*180100 0 FINISH FLOORING
150100 0 HANDRAIL
*120100 0 FINISH MECHANICAL
*160100 0 CLEAN-UP
600400 0 TESTING AND APPROVAL
CODE TYPE DESCRIPTION

UBC CONSTRUCTION MANAGEMENT LAB

Trout Lake Manor - In Details (new Repcon)

REPCON™

ACTIVITY DIARY - WEDNESDAY, 14 OCT 1992

File Used: D:\REP288\PROJ31\MTROUT
Superintendent:
Please sign: _____

Report Date: 24SEP93
Report Time: 16:47:08
Progress Date: 14JAN93
Revision Number: 0 Page 1

WORK ENVIRONMENT DATA

Weather Conditions:
(a) (AM): Clear [ ] Cloudy [ ] Rain [ ] Snow [ ]
(b) (PM): Clear [ ] Cloudy [ ] Rain [ ] Snow [ ]
(c) Temperature: High _____C Low _____C
(d) Precipitation: _____mm
(e) Wind: _____kph
Site Conditions:
(f) Ground conditions: Poor [ ] Fair [ ] Good [ ]
(g) Storage on site: Poor [ ] Fair [ ] Good [ ]
(h) Access to site: Poor [ ] Fair [ ] Good [ ]
Comments:

INSPECTIONS AND TESTS

VISITORS

ACCIDENTS

SITE INSTRUCTIONS

WORK FORCE DATA

Trade	Super # (i)	# (j)	Tradesmen Suf T/M (k)	Tradesmen Skill H/M/L (l)	Tradesmen T/O H/M/L (m)	Tradesmen OvrT HRS (n)
01 EXCAVATION						
04 FORMWORK/CONCRETE						
07 MASONRY						
13 ELECTRICAL						
00						
00						
00						

Comments:

MISCELLANEOUS NOTES

DELIVERIES

Item	Qty & Units	Comment
Concrete		

EQUIPMENT/RENTALS

Rental	Item	Qty	Comment	Status

Status: D=Delivered A=Active I=Idle R=Returned

Fig. 2.2 Typical format for daily site report form

UBC CONSTRUCTION MANAGEMENT LAB

Trout Lake Manor - In Detail (new Repcon)

REPCON™

File Used: D:\REP288\PROJ31\MTROUT

ACTIVITY DIARY - WEDNESDAY, 14 OCT 1992

Report Date: 24SEP93
Report Time: 16:47:18
Progress Date: 14JAN93
Revision Number: 8 Page 2

One day Window. All Project Activities by Resp Code (excluding completed activities). Locations ST to SP.

TRADE NAME	ALT. CODE	ACTIVITY/BACK CHARGE/EXTRA WORK ORDER CODE LOC DESCRIPTION	DATES (A = ACTUAL) START FINSH DUR	5 DAY SCHEDULE TODAY	STATUS TODAY	PROBLEM RESP	PROBLEM CODE	WORK PROGRESS REMARKS/ PROBLEM DESCRIPTIONS	TE MHRS	TIME LOST DAYS	ACTION CODE & NUMBER
EXCAVATION		0113 UG BACKFILL EXT. WALL	A 16SEP 26FEB1114	xx xx XX xx xx	P S O I F						
FORMWORK/C		0401 6 FORM TYPICAL SLAB	A 090CT 160CT 5	xx xx XX xx xx	P S O I F						
		0408 6 INSTALL CABLE IN SLABS	A 140CT 150CT 2	XX xx	P S O I F						
		0414 6 REINF. STEEL IN SLAB	A 130CT 160CT 4	xx XX xx xx	P S O I F						
		0419 MN STAIRWORK & MISC. FORMWORK	A 03SEP 12NOV 47	xx xx XX xx xx	P S O I F						
		0419 2 STAIRWORK & MISC. FORMWORK	A 21SEP 13NOV 38	xx xx XX xx xx	P S O I F						
		0419 3 STAIRWORK & MISC. FORMWORK	A 29SEP 17NOV 34	xx xx XX xx xx	P S O I F						
		0419 4 STAIRWORK & MISC. FORMWORK	A 06OCT 19NOV 31	xx xx XX xx xx	P S O I F						
		0419 5 STAIRWORK & MISC. FORMWORK	A 14OCT 23NOV 28	XX xx xx	P S O I F						
MASONRY		0701 UG MASONRY TO ALL FLOORS	A 01OCT 18NOV 28	xx xx XX xx xx	P S O I F						
ELECTRICAL		1305 6 ELECT CONDUIT IN SLAB	A 130CT 160CT 4	xx XX xx xx	P S O I F						
		1306 6 MECH SLEEVING IN SLAB	A 140CT 140CT 1	XX	P S O I F						
*** OTHER ACTIVITIES											
					P S O I F						
					P S O I F						
					P S O I F						
*** EXTRA WORK ORDERS											
					P S O I F						
					P S O I F						
*** BACK CHARGES											
					P S O I F						
					P S O I F						

ACTIVITY STATUS CODES

F = Finished
I = Idle
O = On-going
P = Postponed
S = Started
* = Critical

PROBLEM SOURCE CODES

00 WORK ENVIRONMENT	10 SITE CONDITIONS	20 OWNER AND CONSULTANTS	30 DESIGN/DRAWINGS	40 WORK FORCE
01 Too much precipitation	11 Insuff storage space	21 Decision(s) required	31 Insuff./Incompl. Drawing	41 Undermanning
02 Too little precipitation	12 Inadequate ext access	22 Changes requested	32 Drawing errors	42 Overmanning
03 Temperature too high	13 Inadequate int access	23 Interf./Stop-work order	33 Design changes/additions	43 Trade stacking
04 Temperature too low	14 Congestion	24 Extra work requested	34 Conflicting information	44 Low skill level
05 Wind too high	15 Site not prepared/ready	25 Awaiting inspection/test	35 Poor design coordination	45 Excessive turnover
06 Excessive humidity	16 Poor ground conditions	26 Excessive quality demand		46 Low motivation/morale
07 Freezr-thaw cycle	17 Unexpected grnd condtns			47 Inadequate instructions
	18 Work space not cleaned			48 Unsafe practices/accid.
				49 Poor trade coordination

50 WORK	60 SUPPLIES AND EQUIPMENTS	70 SCHEDULE	80 UTILTIES/CITY	90 MISCELLANEOUS
51 Rework (Design changes)	61 Insufficient materials	71 Delay of act predecessor	81 Awaiting permits	91 Theft
52 Rework (Workmanship)	62 Insufficient equipment	72 Improper act sequencing	82 Awaiting connections	92 Strikes
53 Rework (Damaged)	63 Late material delivery	73 Out of sequence work	83 Awaiting inspectns/tests	93 Vandalism
54 Rework (Inapp. methods)	64 Late equipment delivery	74 Delay of offsite procur	84 Interference extng util	94 WCB Shutdown
55 Estimating errors	65 Tool/equipment breakdown		85 Damage to extng util.	95 Contract award delay
56 Error in construction	66 Damaged delivery		86 Unanticipated utilities	96 Noise levels too high
57 Layout error	67 Fabrication error(s)			
58 Poor workmanship	68 Poor materials handling			
	69 Wrong equipment			

ACTION CODES

T = Telephone
L = Letter
M = Memo
B = Backcharge
E = Extra Work Order
V = Verbal Instructions

RESPONSIBILITY CODES

G GENERAL CONTRACTOR/CM	10 PAINTING	21 Concrete floor finishing	31 Topping
01 EXCAVATION	11 ROOFING	22 Scaffold remover	32 Skylight
02 SHORING	12 MECHANICAL	23 FIRE SPLINKER SYSTEM	33 Exterior wall finishing
03 ELEVATOR PISTON	13 ELECTRICAL	24 HEATING SYSTEM	34 Ceiling
04 FORMWORK/CONCRETE	14 MILLWORK	25 FIRE STOPPING	35 Water proofing
05 STEEL STUDDING	15 HANDRAILS	26 HVAC	36 TAPE AND FILL
06 DRYWALL BOARDING	16 CLEANUP	27 Laundry Chaute	50 Plumbing engineer
07 MASONRY	18 FLOORING	28 Misc. Metal	51 Electrical engineer
08 ALUM WINDOWS	19 REBAR	29 WALL INSULATOR	52 HVAC consultant
09 METAL DOORS/HARDWARE	20 Architect	30 PIPE INSULATOR	53 Structural engineer

Many discussion sessions were held between the project manager, the superintendent and the author. The meetings were informal, and different approaches for responding to specific problem sources were discussed. The existing compilation of problem sources in the current research version of REPCON was reviewed and critiqued by these individuals.

2.2.5 DATA COLLECTED & OBSERVATIONS

Using the plan and schedule shown in Figure 2.1 as a basis for monitoring the project, the problem source list, and example activity history report shown in Figures 2.3 and 2.4, respectively were produced using the daily site reporting system.

An extended problem source list (see bottom of Figure 2.2) was used for recording problems at the site. A total of thirty-one different problem sources were encountered during my internship. For purposes of the work on automated analysis of daily site records, only a subset of the problem sources were treated.

There were difficulties associated with the collection of site data. Oberlender (1989) came to the same conclusion that obtaining the information from the site can be most difficult. It is realistic to say that the data set collected does not reflect all problems encountered. On any given day, some could be missed because my site duties required me to focus my attention on specific parts of the project. (This is the same situation faced by a superintendent. The larger the site and/or the project, the more difficult it is for one person to have a complete view of progress and problems.) Others were not recorded because they were resolved very quickly. Nevertheless, I believe that I have recorded the major difficulties encountered during my time on site.

UBC CONSTRUCTION MANAGEMENT LAB

REPCON™

Trout Lake Manor - In Details (new Repcon)

DAILY SITE PROBLEM SOURCES REPORT

File Used: D:\REP200\PROJ87\TROUT
Report Period: 14JUL92 - 28JAN93
All Problem Codes for All Activities.

* Critical	E Extra Work Order
x Non-worked Day	L Letter
' Unscheduled	M Memo
B Backcharge	T Telephone

Report Date: 02SEP93
Report Time: 17:55:25
Progress Date: 14JAN93
Revision Number: 0

DATE	ACTIVITY/EXTRA WORK ORDER/BACK CHARGE CODE	LOC	RESP	DESCRIPTION	PROBLEM DESCRIPTION	PROBLEM RESPONSIBILITY CODE	NAME	ACTION CODES	MAN HOURS LOST EST	ADJ	TOTAL	DAYS LOST EST	ADJ	TOTAL
PROBLEM: (1) Too much precipitation														
21JUL92	' 010900	UG		01 WATER PROOFING	Rain prevented water proofing in the exterior wall.				6.00		6.00			
16DEC92	030200	UG		03 INSTALL ELEVATOR	Too much water in hole for elevator crew to work on. Need to pump water out.				2.00		2.00			
21DEC92	' C00600	MN		G TOPPING	Some parts of floor are too wet to laying topping on. Use heater to warm the floor.				5.00		5.00	0.50		0.50
29DEC92	330100	MN		33 STUCCO	SNOW AND BAD WEATHER DELAY ACTIVITY							2.00		2.00
31DEC92	330100	MN		33 STUCCO	SNOW AND BAD WEATHER DELAY ACTIVITY							2.00		2.00
								-SUBTOTALS	13.00		13.00	4.50		4.50
PROBLEM: (4) Temperature too low														
07JAN93	' C00600	2		G TOPPING	WATER LINE FROZE AT 3:00PM. NEED TO FINISH OFF TOMORROW MORNING.							0.50		0.50
								SUBTOTALS				0.50		0.50
PROBLEM: (5) Wind too high														
04SEP92	' 041900	MN		04 STAIRWORK & MISC. FORMWORK	Wind too high, crane shut down at 10:30am. Cannot pour stair today. Reschedule the pour to next working day.			T To Lafarge for res				1.00		1.00
								SUBTOTALS				1.00		1.00
PROBLEM: (6) Excessive humidity														
28DEC92	' 060600	MN		06 CEILING-WEST	CONDENSATION IN OFFICE'S AREA OF MAIN FLOOR. USE HEATER TO WARM THE ROOM UP AND TRY TO BURN OFF THE MOISTURE IN THE AIR.				2.00		2.00	1.50		1.50
								SUBTOTALS	2.00		2.00	1.50		1.50
PROBLEM: (14) Congestion														
02SEP92	' 040100	2		04 FORM TYPICAL SLAB	Congested site due to massive materials on site like forms for decking scaffolds, plywood etc laying around in the site. Interior access problem	04	FORMWORK/CONCRETE		1.00		1.00			
04SEP92	' 040100	2		04 FORM TYPICAL SLAB	Congested site causes internal access problem and storage problem.									
08SEP92	040100	2		04 FORM TYPICAL SLAB	Congested site for trades to work on the 2nd floor deck. Limit amount of space on site costs internal access problem and storage problem.									
18SEP92	040100	2		04 FORM TYPICAL SLAB	Temperary storage on site, stack of rebars and scaffolds etc affect internal access of workers on site				1.00		1.00			
28SEP92	' 041400	4		04 REINF. STEEL IN SLAB	Congested site today. Too many trades are working on the deck to try to get the slab in by Sep 30.				1.00		1.00			

Fig. 2.3 Daily site problem sources report

DATE	ACTIVITY/EXTRA WORK ORDER/BACK CHARGE CODE	LOC	RESP	DESCRIPTION	PROBLEM DESCRIPTION	PROBLEM RESPONSIBILITY CODE	NAME	ACTION CODES	MAN HOURS LOST F_EST	ADJ	TOTAL	DAYS LOST F_EST	ADJ	TOTAL
								SUBTOTALS	3.00		3.00			
PROBLEM: (15) Site not prepared/ready														
28AUG92	041000	MM		04 FORM & POUR WALLS/COLUMNS	Westkamp did not have one column ready in time to pour. Waste 0.46 m^3 of concrete.	04	FORMWORK/CONCRETE	B Return unuse porti						
								SUBTOTALS						
PROBLEM: (18) Work space not cleaned														
08SEP92	040100	Z		04 FORM TYPICAL SLAB	Westkamp hadn't clean out the 2nd floor slab for the elect. and mech.. This had delayed both activities of roughing in mech. and elect. Slow progress of mech. and elect. was observed.	04	FORMWORK/CONCRETE	V To Tim of Westkamp	4.00		4.00			
01OCT92	! 070100	UG		07 MASONRY TO ALL FLOORS	BASEMENT HAS NOT BEEN CLEANED THROUGHLY BY WESTKAMP. NEED SCOTT LABOR TO HELP CLEAN THE BASEMENT	04	FORMWORK/CONCRETE							
13OCT92	070100	MM		07 MASONRY TO ALL FLOORS	Main floor not clean for layout of masonry and other trade. Westkamp had not started cleaning until late in the afternoon. Difficult in layout.	04	FORMWORK/CONCRETE		2.00		2.00			
	120000	MM		12 R.I. PLUMBING	Main floor not cleaned for plumber to work on.	04	FORMWORK/CONCRETE					1.00		1.00
14OCT92	070100	MM		07 MASONRY TO ALL FLOORS	Work space still too dirty for trade to work on.	04	FORMWORK/CONCRETE					1.00		1.00
	120000	MM		12 R.I. PLUMBING	Dust from grind all over the floor.	04	FORMWORK/CONCRETE					0.10		0.10
26OCT92	! 050400	MM		05 INT. STEEL STUDS	Workspace not cleaned for interior steel stud to work on.	04	FORMWORK/CONCRETE					0.50		0.50
18NOV92	! 050400	3		05 INT. STEEL STUDS	Seymour stated that work space not clean on 3rd floor for layout in the west side. Do so and comply at 11am	G	GENERAL CONTRACTOR					0.40		0.40
								SUBTOTALS	6.00		6.00	3.00		3.00
PROBLEM: (22) Changes requested														
24AUG92	! 120700	MM		12 R.I. ELEC & MECH-MM-SLAB-WES	Architect requested changes in entrance of the building. Auto. door mechanism. Need to rearrange mark on slab and changing the landscape drawing (Original plans have plants in front of the new entrance).	28	Architect							
								SUBTOTALS						
PROBLEM: (24) Extra work requested														
24AUG92	! 041000	MM		04 REINFORING STEEL-MM-WEST	Westkamp requested pour West MM slab on Tuesday, 25th August,1992. Need accelerate to accomodate the tight schedule	04	FORMWORK/CONCRETE							
								SUBTOTALS						
PROBLEM: (31) Insuff./Incompl. Drawing														
28JUL92	011000	UG		01 INSTALL PLUMBING-WEST	Russell Food drawings have no measurement. Waiting for information to complete plumbing.									
	120300	UG		12 INSTALL UG MECH - WEST	Russell's Food drawings have no measurement. Need more information for UG utilities in the kitchen.				4.00		4.00			
17AUG92	120700	MM		12 R.I. ELEC & MECH-MM-SLAB-WES	Plumber has problem in landscape drawing. Need additional drainage in landscape area but drawing is incomplete in showing the location, and number of outlet. Will discuss with D. Lee tomorrow to sort it out	12	MECHANICAL							
								SUBTOTALS	4.00		4.00			
PROBLEM: (32) Drawing errors														
18AUG92	120700	MM		12 R.I. ELEC & MECH-MM-SLAB-WES	Laundry chute area layout problem. Need structural engineer coming in to sort it out.									

DATE	ACTIVITY/EXTRA WORK ORDER/BACK CHARGE CODE	LOC	RESP	DESCRIPTION	PROBLEM DESCRIPTION	PROBLEM RESPONSIBILITY CODE	NAME	ACTION CODES	MAN HOURS LOST F_EST	ADJ	TOTAL	DAYS LOST F_EST	ADJ	TOTAL
04SEP92	! 040100	2	04	FORM TYPICAL SLAB	Architect has not considered the size of the mech. needed in steel studs. Many time he designed the stud too small for the mechanical and elect. to fit inside properly	20	Architect							
								SUBTOTALS						
PROBLEM: (33) Design changes/additions														
09NOV92	230100	MM	23	FIRE SPRINKLER MAIN	Design changes in the height for sprinkler. Need to chord new hole for sprinkler through wall F3-F4 and inner wall of radius stairwall.	20	Architect					1.00		1.00
								SUBTOTALS				1.00		1.00
PROBLEM: (35) Poor design coordination														
02NOV92	! 120000	3	12	R.I. PLUMBING	Have coordination problem with sheet metal guy. Pipe in the way of air duct. Need relocation of pipe.	20	Architect		4.00		4.00			
								SUBTOTALS	4.00		4.00			
PROBLEM: (41) Undermanning														
21AUG92	! 041000	MM	04	REINFORING STEEL-MM-WEST	Not enough worker on the site. Delay progress of rebar laying and electrical pipes laying, which required all bottom layer of reinfor. to be done. Will work on Sat to make up time for pour on Tuesday.	04	FORMWORK/CONCRETE	T O. Lee called reba	4.00		4.00			
13OCT92	120000	MM	12	R.I. PLUMBING	Not enough man to preform activity. One additional man supposed to come for plumbing but did not show up.	12	MECHANICAL					1.00		1.00
14OCT92	120000	MM	12	R.I. PLUMBING	Not enough man for trade to work on floor. Trade promise will try to find more men.	12	MECHANICAL					0.50		0.50
15OCT92	120000	MM	12	R.I. PLUMBING	Can use one more man for piping at main floor.	12	MECHANICAL					0.30		0.30
03NOV92	G00300	2	G	WINDOW LINER	Long than expected.	G	GENERAL CONTRACTOR							
04NOV92	! G00300	2	G	WINDOW LINER		G	GENERAL CONTRACTOR							
05NOV92	! G00300	2	G	WINDOW LINER		G	GENERAL CONTRACTOR							
06NOV92	! G00300	3	G	WINDOW LINER		G	GENERAL CONTRACTOR							
09NOV92	! G00300	3	G	WINDOW LINER		G	GENERAL CONTRACTOR							
10NOV92	! G00300	3	G	WINDOW LINER		G	GENERAL CONTRACTOR							
12NOV92	! G00300	3	G	WINDOW LINER		G	GENERAL CONTRACTOR							
15DEC92	! 240300	MM	24	IN-FLOOR HEATING-EAST	Not enough man for the activity. Finish only 2 room today.	24	HEATING SYSTEM					0.75		0.75
16DEC92	! 240300	MM	24	IN-FLOOR HEATING-EAST	Not enough man power for the trade.	24	HEATING SYSTEM					0.50		0.50
22DEC92	240300	2	24	IN-FLOOR HEATING-EAST	NOT ENOUGH MANPOWER FOR ACTIVITY. NEED MORE MEN IN SHOOTING PINS ONTO FLOOR.	24	HEATING SYSTEM					0.60		0.60
23DEC92	! 240300	2	24	IN-FLOOR HEATING-EAST	NEED ONE MORE MAN FOR SHOOTING PINS ONTO SLAB.	24	HEATING SYSTEM					0.60		0.60
24DEC92	! 240300	2	24	IN-FLOOR HEATING-EAST	NOT ENOUGH MEN TO SHOOT PINS ONTO SLAB.	24	HEATING SYSTEM					0.30		0.30
28DEC92	! 230100	5	23	FIRE SPRINKLER MAIN	WORKER'S ON HOLIDAYS DURING CHRISMAS SEASON.	23	FIRE SPLINKER SYST					3.00		3.00
29DEC92	860300	3	86	BOARDING-WEST	NOT ENOUGH MEN TO WORK ON PROJECT DURING HOLIDAY SEASON.	86	DRYWALL BOARDING					2.00		2.00
30DEC92	! 860300	3	86	BOARDING-WEST	UNDERMANNING: ONLY 2 DRYWALL BOARDER WORKING TODAY.	86	DRYWALL BOARDING					0.60		0.60
31DEC92	! 230100	5	23	FIRE SPRINKLER MAIN	WORKER IS ON HOLIDAY.	23	FIRE SPLINKER SYST					1.00		1.00
04JAN93	860300	3	86	BOARDING-WEST		86	DRYWALL BOARDING					0.25		0.25
	860000	3	86	BOARDING-EAST		86	DRYWALL BOARDING					0.50		0.50
05JAN93	230300	4	23	SPRINKLER HEADS	DID NOT SHOW UP FOR SPRINKLER HEADS CONNECTION.	23	FIRE SPLINKER SYST					1.00		1.00
06JAN93	861000	MM	86	TAPE AND FILL-EAST	NO TAPER ON SITE?	86	DRYWALL BOARDING							
07JAN93	! 860500	MM	86	TAPE AND FILL-WEST	NO TAPER ON SITE TODAY?	86	DRYWALL BOARDING					1.00		1.00
	861000	MM	86	TAPE AND FILL-EAST	NO TAPER ON SITE?									
11JAN93	861100	2	86	CEILING-EAST	CEILING CREW DID NOT SHOW UP TODAY.	86	DRYWALL BOARDING							
12JAN93	861100	2	86	CEILING-EAST	CEILING CREW DID NOT SHOW UP TODAY.	86	DRYWALL BOARDING					1.00		1.00
								SUBTOTALS	4.00		4.00	14.90		14.90

DATE	ACTIVITY/EXTRA WORK ORDER/BACK CHARGE CODE	LOC	RESP	DESCRIPTION	PROBLEM DESCRIPTION	PROBLEM RESPONSIBILITY CODE	NAME	ACTION CODES	MAN HOURS LOST F_EST	ADJ	TOTAL	DAYS LOST F_EST	ADJ	TOTAL
PROBLEM: (43) Trade stacking														
	! 050400	MN	05	INT. STEEL STUDS	Steel stud said HVAC subtrade is in his way all the time. Want HVAC to continue to stop for now or continue whereelse for the time being.									
								SUBTOTALS						
PROBLEM: (45) Excessive turnover														
08OCT92	041000	5	04	FORM & POUR WALLS/COLUMNS	Many worker left the job due to underpayment by subtrade owner. Hire many new worker from outside source.	04	FORMWORK/CONCRETE					0.50		0.50
09OCT92	! 040100	6	04	FORM TYPICAL SLAB	Hire new crew men to site	04	FORMWORK/CONCRETE		3.00		3.00			
	041000	5	04	FORM & POUR WALLS/COLUMNS	Many worker left subcontractor's company. Find new men from outside source.	04	FORMWORK/CONCRETE		3.00		3.00			
13OCT92	! 040100	6	04	FORM TYPICAL SLAB	Hiring new crewmen from outside due to worker left site.	04	FORMWORK/CONCRETE							
								SUBTOTALS	6.00		6.00	0.50		0.50
PROBLEM: (47) Inadequate instructions														
04NOV92	050400	MN	05	INT. STEEL STUDS	Await for information in layout for west side of the building.	20	Architect					1.00		1.00
16NOV92	050400	MN	05	INT. STEEL STUDS	In wall layout on the west side on main floor, architect has not been finalize the wall thickness and layout. Await for information	20	Architect					4.00		4.00
17NOV92	! 240100	MN	24	R.I. HVAC	Require instruction on the layout for the air duct in the west side of main floor. Distribute manpower to other floor wait awaiting for information	52	HVAC consultant					3.00		3.00
								SUBTOTALS				8.00		8.00
PROBLEM: (48) Unsafe practices/accid.														
21SEP92	! 040100	3	04	FORM TYPICAL SLAB	Westkamp had only 20% of safety handrail installed on the 3rd floor deck. Unsafe work condition for workers.	04	FORMWORK/CONCRETE	V Talk to Westkamp's						
28DEC92	! 050400	5	05	INT. STEEL STUDS	WHOLE CREW OF SEYMOUR WALKED OUT ON JOB TODAY AT 11:45AM DUE TO UNCOORPERATIVE IN COMPLYING WCB SAFETY REQUIREMENTS.	05	STEEL STUDDING					0.50		0.50
	060300	3	06	BOARDING-WEST	WORKERS UNWILLING TO COMPLY WITH WCB SAFETY REQUIREMENT. ASK TO LEAVE SITE.	06	DRYWALL BOARDING					0.50		0.50
								SUBTOTALS				1.00		1.00
PROBLEM: (53) Rework (Damaged)														
14DEC92	240300	MN	24	IN-FLOOR HEATING-EAST	Have problem with rubber heating pipe - appear that those pipes have been used. Stay for 1/2 day only. Finish only 1/2 a room				4.00		4.00	1.00		1.00
								SUBTOTALS	4.00		4.00	1.00		1.00
PROBLEM: (55) Estimating errors														
								SUBTOTALS						
PROBLEM: (56) Error in construction														
03SEP92	! 041000	MN	04	FORM & POUR WALLS/COLUMNS	Tim just found out that his verticals are 1" higher than specification Informed Bill and Mr. Lee and ask if it is ok. MG. Need to use kengo to chip all the extra concrete out. 1 man chipped all day.	04	FORMWORK/CONCRETE		8.00		8.00			
04SEP92	! 040100	2	04	FORM TYPICAL SLAB	Wrong estimation of height makes the vertical pour 1" higher than specification. One man from Westkamp chipped the extra concrete off	04	FORMWORK/CONCRETE		4.00		4.00			

DATE	ACTIVITY/EXTRA WORK ORDER/BACK CHARGE CODE	LOC	RESP	DESCRIPTION	PROBLEM DESCRIPTION	PROBLEM RESPONSIBILITY CODE	NAME	ACTION CODES	MAN HOURS LOST F_EST	ADJ	TOTAL	DAYS LOST F_EST	ADJ	TOTAL
					from the verticals									
08SEP92	040100	2	04	FORM TYPICAL SLAB	One man chipping extra 1" concrete off top of verticals all day.	04	FORMWORK/CONCRETE		8.00		8.00			
09SEP92	040100	2	04	FORM TYPICAL SLAB	One man from Westkamp chipping extra 1" concrete from vertical all day. Finish today.	04	FORMWORK/CONCRETE		8.00		8.00			
21SEP92	! 041900	2	04	STAIRWORK & MISC. FORMWORK	Key in stair on south eastern side between 2nd and 3rd floor is in wrong location. One man chipped concrete for proper location of key all day	04	FORMWORK/CONCRETE		8.00		8.00			
23SEP92	! 041900	2	04	STAIRWORK & MISC. FORMWORK	Part of main elevator out of plumb approximately 1". Two men from Westkamp tried to correct problem in the morning.	04	FORMWORK/CONCRETE		4.00		4.00			
30OCT92	! 130000	MM	13	ELECTRICAL & CABLE TV R.I.	Use kango to chip concrete for off location pipe.	13	ELECTRICAL		2.00		2.00			
19NOV92	050300	4	05	EXTERIOR STEEL STUD & DRYWAL	Need rework for wrong stud	05	STEEL STUDDING		0.50		0.50			
30DEC92	030200	UG	03	INSTALL ELEVATOR	PROBLEM IN PISTON: IT IS NOT STRAIGHT VERTICALS DOWN WHICH REQUIRED BY ELEVATOR SUBTRADE. MAY OFFSET CENTER BY 6" BUT NEED SCOTT TO POUR SAND + CONCRETE ONCE LOCATION IS SET.				5.00		5.00	0.50		0.50
								SUBTOTALS	47.50		47.50	0.50		0.50
PROBLEM: (57) Layout error														
18AUG92	120700	MM	12	R.I. ELEC & MECH-MM-SLAB-WES	Problem re. laundry chute. Mech. cap doesn't fit in such tight space. Have Scott, mech. subtrade and structural engineer together to solve problem.									
25AUG92	! 041000	MM	04	FORM & POUR WALLS/COLUMNS	Architect changes the interior wall in C1 and 2 (next to stair) from 3'8" to 5'. Need to figure out solution on site and inform architect.	28	Architect							
22OCT92	120800	MM	12	R.I. PLUMBING	Plumber is chipping concrete for holes of wrong rough-in location. One man did that for whole day.	12	MECHANICAL		8.00		8.00			
23OCT92	120800	MM	12	R.I. PLUMBING	Continue to chipping concrete on wrong location of cans at MM.	12	MECHANICAL		3.00		3.00			
26OCT92	120800	MM	12	R.I. PLUMBING	Continue to chip concrete for wrong location of canning. Mostly done.	12	MECHANICAL		2.00		2.00			
03NOV92	! 230100	MM	23	FIRE SPRINKLER MAIN	Wrong location of canning in some areas on wall. Need chipping on some walls so that the fire sprinkler remains same height.				3.00		3.00	1.00		1.00
								SUBTOTALS	16.00		16.00	1.00		1.00
PROBLEM: (58) Poor workmanship														
02SEP92	041000	MM	04	FORM & POUR WALLS/COLUMNS	Elevator wall in north did not have enough tie rods and brace in forms The wall bulge out past wall line requirement during the pour. Remedial work will have to be done.	04	FORMWORK/CONCRETE	M Speed Memo to West						
03SEP92	! 041000	MM	04	FORM & POUR WALLS/COLUMNS	Elevator shaft at A4 is not acceptable. Lack of tie rods and bracing etc. in the forms caused wall to bulge out past wall line requirement. Remedial work will have to be done.	04	FORMWORK/CONCRETE	M Speed memo to Tim V Verbal at Sept 3,						
24NOV92	110100	RF	11	ROOFING	Materials did not stick properly to edge. Inspection not approved. Mainly due to poor workmanship for the material did not put on at the boiling temperature of the tar.	11	ROOFING		4.00		4.00	1.50		1.50
22DEC92	110200	RF	11	REMEDIAL FOR ROOFING	NEED MATERIAL OVERHANGED CURB FOR SKYLIGHT. NEED TO REBUILD TEMP. ROOF TO PREVENT RAIN. DELAY INSTALLATION OF SKYLIGHT AND WASTE SKYLIGHT'S WORKERS TIME AND MONEY.	11	ROOFING		30.00		30.00	1.00		1.00
28DEC92	! 061100	MM	06	CEILING-EAST	HOLES IN CEILING DUE TO POOR WORKMANSHIP OF FORMWORK NEEDED TO BE PATCHED UP BEFORE SMOOTHEN THE CEILING.	04	FORMWORK/CONCRETE		4.00		4.00			
								SUBTOTALS	38.00		38.00	2.50		2.50
PROBLEM: (61) Insufficient materials														
28DEC92	! 050400	S	05	INT. STEEL STUDS	DOES NOT HAVE ENOUGH 6" STEEL STUD TO FINISH OFF FLOOR. LOST AT LEAST 3 DAYS IN WAITING FOR MATERIALS.	05	STEEL STUDDING					3.50		3.50
31DEC92	! 050400	S	05	INT. STEEL STUDS	6" STEEL STUD STILL NOT AVAILIBLE. CAN'T FINISH 5TH FLOOR.	05	STEEL STUDDING					2.00		2.00

DATE	ACTIVITY/EXTRA WORK ORDER/BACK CHARGE CODE	LOC	RESP	DESCRIPTION	PROBLEM DESCRIPTION	PROBLEM RESPONSIBILITY CODE	NAME	ACTION CODES	MAN HOURS LOST F_EST	ADJ	TOTAL	DAYS LOST F_EST	ADJ	TOTAL
								SUBTOTALS				5.50		5.50
PROBLEM: (62) Insufficient equipment														
12NOV92	! 042000	6	04	MISC. CURB WALLS	Tight crane time. Time reserved for pouring taken up by Westkamp for loading shore offsite. Delay pour from 3:00 to 3:30pm. Add overtime 1/2 hr for SCOTT employees.	04	FORMWORK/CONCRETE		3.00		3.00			
	! 050400	2	05	INT. STEEL STUDS	Tight crane time. Materials cannot be lifted to the floor in time. Need to await to load off material by hand on the side.				2.00		2.00			
13NOV92	! 070100	6	07	MASONRY TO ALL FLOORS	No crane time. Material for brick layer can't be lifted up to proper floor. Will try to do so on Monday.							1.00		1.00
17NOV92	070100	3	07	MASONRY TO ALL FLOORS	No crane time in lifting material to the floor. Idle when waiting for crane.				5.00		5.00	0.50		0.50
								SUBTOTALS	10.00		10.00	1.50		1.50
PROBLEM: (63) Late material delivery														
11AUG92	! 041600	MM	04	FORM MAIN FLOOR SLAB-WEST	Scaffolding supposed to come in at 7:30am. Arrived in site at 1:45pm. Delay the building of scaffolding to next day							1.00		1.00
21AUG92	! 041000	MM	04	REINFORING STEEL-MM-WEST	Rebar did not arrive today until 3:00pm in the afternoon. Rebar guy did not have enough material to finish off kitchen area.				2.00		2.00			
26AUG92	040600	MM	04	REFORCING STEEL-MM-EAST	Rebar steel did not arrive in morning. Workers cannot start bottom steel. This delayed both rebar personnel and electrican, who required the bottom lay of rebar to be done before starting.									
18SEP92	040000	2	04	INSTALL CABLE IN SLABS	PT cable did not arrive to site today. Cannot install cable on sec. floor slab. Reassign workers to prefabricate rebar in vertical for the second floor.			T To Richfield				1.00		1.00
								SUBTOTALS	2.00		2.00	2.00		2.00
PROBLEM: (65) Tool/equipment breakdown														
24SEP92	041000	3	04	FORM & POUR WALLS/COLUMNS	Crane broke down today at around 2:00pm. Pour concrete for columns at the time. Had to send about 5.0cm of concrete back to plant at 4:00pm for it has been stayed too long.			T For repair at 2:15	12.00		12.00	0.50		0.50
21DEC92	! G00600	MM	G	TOPPING	Pump for topping break down sometimes in the morning. Finish a small part of the total floor only.							0.75		0.75
								SUBTOTALS	12.00		12.00	1.25		1.25
PROBLEM: (69) Wrong equipment														
17SEP92	! 040100	3	04	FORM TYPICAL SLAB	Uwacs delivery wrong braces to the site. Size too small			T Inform. Uwacs; Del						
08OCT92	041000	S	04	FORM & POUR WALLS/COLUMNS	Masonry pump inadequate to pour curb wall on main. Three inches pipe got stucked frequently. Eventually got it to work. Start at 3:00pm. Finished at 5:30pm	04	FORMWORK/CONCRETE		6.00		6.00			
								SUBTOTALS	6.00		6.00			
PROBLEM: (71) Delay of act predecessor														
21SEP92	! 041400	3	04	REINF. STEEL IN SLAB	Because forming did not finish all formwork on the third deck at the beginning of the morning, rebar cannot start on third deck effectively Lost about 1 hr in time lost.	04	FORMWORK/CONCRETE					0.13		0.13
	! 130500	3	13	ELECT CONDUCT IN SLAB	Electircal can't start installing electrical conduit because bottom steel and cables haven't been finished laying yet.	04	FORMWORK/CONCRETE					1.00		1.00
29SEP92	! 130500	4	13	ELECT CONDUCT IN SLAB	Electrical cannot lay electrical pipe unless a large portion of bottom steel is laid. Hold up by Rebar partially. Work in UG during the	19	REBAR					0.10		0.10

DATE	ACTIVITY/EXTRA WORK ORDER/BACK CHARGE CODE	LOC	RESP	DESCRIPTION	PROBLEM DESCRIPTION	PROBLEM RESPONSIBILITY CODE	NAME	ACTION CODES	MAN HOURS LOST F_EST	ADJ	TOTAL	DAYS LOST F_EST	ADJ	TOTAL
					awhile period.									
30SEP92	! 040900	4		04 PLACE SLAB	Westkamp said the deck would be ready by 11:00am. Actual start around 11:25am. Delay schedule caused hold up of concrete twice in the day. Finish pour by 8:00pm.	04	FORMWORK/CONCRETE		10.00		10.00			
140CT92	! 041400	6		04 REINF. STEEL IN SLAB	Deck wasn't finished until 11 o'clock. Cannot work on west side until deck finished.	04	FORMWORK/CONCRETE					0.38		0.38
	120800	MM		12 R.I. PLUMBING	Still waiting for grinding of ceiling to be finished.	04	FORMWORK/CONCRETE					1.00		1.00
	! 130500	6		13 ELECT CONDUCT IN SLAB	Deck work did finish until 11 o'clock. Electrical cannot start on west side of the building. Relocate manpower to work in basement during awaiting time	04	FORMWORK/CONCRETE					0.50		0.50
280CT92	! 042800	6		04 MISC. CURB WALLS	DELAY POUR BY 30 MINUTES DUE TO ACTIVITY NOT READY. ASKED FOR CONCRETE AT 2:30PM. FINISH POUR AT 4:30PM.	04	FORMWORK/CONCRETE							
03NOV92	! 042800	6		04 MISC. CURB WALLS	Delay in pouring curb wall at 06 floor. Schedule at 3:00pm. Pour at 3:15pm	04	FORMWORK/CONCRETE							
11DEC92	080300	6		08 WINDOW INSTALLION	Window on 6th floor cannot finish without the liner and/or Tyvek on. Finish as much as possible and will come back later to compplete.	06	DRYWALL BOARDING					0.50		0.50
30DEC92	! 240300	2		24 IN-FLOOR HEATING-EAST	HEATING HAS BEEN ORDERED TO WORK ON OTHER ROOM THAN LOUNGE SO THAT THE MASONRY SUBTRADE WILL NOT STEP ON HEATING PIPE WHEN INSTALLING GLASSBLOCK. (DELAY SHIPPMENT OF GLASS BLOCK)	07	MASONRY					0.25		0.25
								SUBTOTALS	10.00		10.00	3.78		3.78
PROBLEM: (74) Delay of offsite procur														
15JUL92	040300	UG		04 FORM/POUR WLL/COL PARKADE	DELAY OF CONCRETE DELIVERY. ARRANGE AT 2 O'CLOCK BUT TRUCK CAME AT 2:50PM. OVERTIME WORK FOR POURING WAS NEEDED.	04	FORMWORK/CONCRETE							
								SUBTOTALS						
PROBLEM: (94) WCB Shutdown														
04SEP92	! 040100	2		04 FORM TYPICAL SLAB	Tilted power pole is unsafe for the workers in site. Bill called Hydro and WCB. WCB shut down site for the afternoon			T Hydro came and fix				0.50		0.50
	! 130500	2		13 ELECT CONDUCT IN SLAB	Unsafe site due to tilted power pole in Porter street.							0.50		0.50
								SUBTOTALS				1.00		1.00
								TOTALS	187.50		187.50	55.93		55.93

UBC CONSTRUCTION MANAGEMENT LAB

REPCON™

Trout Lake Manor - In Details (new Repcon)

DAILY SITE HISTORY REPORT

File Used: D:\REP200\PROJ31\NTROUT
Report Period: 07MAY92 - 14JAN93
By Responsibility Code (04).

* Critical	E Extra Work Order
x Non-worked Day	L Letter
! Unscheduled	M Memo
B Backcharge	T Telephone

Report Date: 29SEP93
Report Time: 10:53:54
Progress Date: 14JAN93
Revision Number: 0

LOC	SCHEDULED/EARLY START	SCHEDULED/EARLY FINISH	SCHEDULED/EARLY DUR	ACTUAL START	ACTUAL FINISH	REM DUR	DATE & STATUS	PROBLEM RESP CODE	REMARKS & PROBLEM DESCRIPTION	ACTION	MAN HOURS LOST F_EST	MAN HOURS LOST ADJ	MAN HOURS LOST TOTAL	DAYS LOST F_EST	DAYS LOST ADJ	DAYS LOST TOTAL
Activity: 040100 FORM TYPICAL SLAB																
2	03SEP92	17SEP92	9	01SEP92	10SEP92	6	01SEP92 S		(RE) Start building scaffolding for 2nd floor slab in the afternoon.							
							02SEP92 0		(RE) New load of scaffolding arrived in the morning. Continue to set up scaffolds for 2nd slab. Install forms for center stairwall (W. curve)							
								04 (14)	Congested site due to massive materials on site like forms for decking scaffolds, plywood etc laying around in the site. Interior access problem		1.00					
							03SEP92 0		(RE) Laying scaffolding in the east side of the building. 75% west side plywood. 25% south side scaffolding.							
							x04SEP92 0		(RE) Form along east wing of the building. Install scaffolds and lay decking.							
									(14) Congested site causes internal access problem and storage problem.							
								28 (32)	Architect has not considered the size of the mech. needed in steel studs. Many time he designed the stud too small for the mechanical and elect. to fit inside properly							
								04 (56)	Wrong estimation of height makes the vertical pour 1" higher than specification. One man from Westkamp chipped the extra concrete off from the verticals		4.00					
									(94) Tilted power pole is unsafe for the workers in site. Bill called Hydro and WCB. WCB shut down site for the afternoon	T Hydro came and fix over weekend.				0.50		
							08SEP92 0		(RE) Still haven't finished forming 2nd floor deck. Delay plumbing and electrical.							
									(14) Congested site for trades to work on the 2nd floor deck. Limit amount of space on site costs internal access problem and storage problem.							
								04 (18)	Westkamp hadn't clean out the 2nd floor slab for the elect. and mech.. This had delayed both activities of roughing in mech. and elect. Slow progress of mech. and elect. was observed.	V To Tim of Westkamp.	4.00					
								04 (56)	One man chipping extra 1" concrete off top of verticals all day.		8.00					
							09SEP92 0		(RE) 2nd slab is 98% finished.							
								04 (56)	One man from Westkamp chipping extra 1" concrete from vertical all day. Finish today.		8.00					
							10SEP92 F		(RE) Minor deck work							
									(14) Temperary storage on site, stack of rebars and scaffolds etc affect internal access of workers on site		1.00					
3	23SEP92	01OCT92	7	17SEP92	21SEP92	3	17SEP92 S		(RE) Delivery at 11:30am							
									(69) Unacs delivery wrong braces to the site. Size too small	T Inform. Unacs; Deliver tomorrow						
							18SEP92 0		(RE) Start and continue working on third deck.							
							21SEP92 F		(RE) Deck finished in the morning.							
								04 (48)	Westkamp had only 20% of safety handrail installed on the 3rd floor deck. Unsafe work condition for workers.	V Talk to Westkamp's owners & foreman						
4	30SEP92	05OCT92	4	25SEP92	30SEP92	4	25SEP92 S		(RE) Start working overtime on north wing.							
							x26SEP92 0		(RE) Setting up scaffolds and plywood for 4th floor deck north wing and part east wing.							
							28SEP92 0		(RE) Forming suspended slab east wing. Work late to finish. Minor work to go in north wing. Stripped stair at F3-F4. 70% finished							

Fig. 2.4 Example activity history report

LOC	SCHEDULED/EARLY START	FINISH	DUR	ACTUAL START	FINISH	REM DUR	DATE & STATUS	PROBLEM RESP CODE	REMARKS & PROBLEM DESCRIPTION	ACTION	MAN HOURS LOST F_EST	ADJ	TOTAL	DAYS LOST F_EST	ADJ	TOTAL
Activity: 040100 FORM TYPICAL SLAB																
							29SEP92	0	(RE) Minor job on deck. Mainly finish.							
							30SEP92	F	(RE) Clean out deck with blower. Minor work in bobcaps and handrail.							
5	14OCT92	19OCT92	4	02OCT92	07OCT92	4	02OCT92	S	(RE) Start setting up scaffolding from east wing							
							x03OCT92	0	(RE) Setting up scaffolding on the 5th floor deck							
							05OCT92	0	(RE) 90% completed. Need to finish west wing tomorrow.							
							06OCT92	0								
							07OCT92	F	(RE) Continue working on curb wall on main. Start installing curb wall.							
6	16OCT92	21OCT92	4	09OCT92	16OCT92	5	09OCT92	S	(RE) Start scaffolding from the east end of the building. Start around 10:00 a.m.							
							04 (45)		Hire new crew men to site		3.00					
							x10OCT92	0	(RE) Setting up scaffolding for the deck.							
							13OCT92	0	(RE) Deck is 80% done at the end of day.							
							04 (45)		Hiring new crewmen from outside due to worker left site.							
							14OCT92	0	(RE) Deck wasn't finished until 11 o'clock. Still has boardcaps to install and stairwork at F3-F4.							
							15OCT92	0	(RE) 95% completed. STill working on curb wall on slab.							
							16OCT92	F								
MF	22OCT92	28OCT92	5	22OCT92	29OCT92	6	22OCT92	S	(RE) Start setting up scaffolds for roof. Completed approximately 40% of the deck.							
							23OCT92	0	(RE) Continue to set up scaffolds for the roof.							
							26OCT92	0	(RE) Continue formwork on deck. 60% completed.							
							27OCT92	0	(RE) Form opening for skylight on roof.							
							28OCT92	0	(RE) 95% of deck finished. Will pour roof slab on Friday.							
							29OCT92	F	(RE) Minor work today.							
										SUBTOTALS	29.00			0.50		

Various problem sources were encountered on a recurring basis, such as undermanning, errors in construction and drawing errors (see Figure 2.3). An enormous amount of time was spent requesting additional information and clarifications. These problem sources had a negative impact on the cost, time and quality aspects of the project. Some problems affected ongoing activities, while others affected activities not scheduled to start until several weeks later. Different corrective actions were utilized in order to ensure a continuous flow of work.

In terms of detailing and accuracy, the architectural drawings for the building were of very poor quality. Too many errors and mistakes were found in the drawings and they required substantial time to resolve. To help cope with such problems, JCS changed its foreman to a more experienced one to help the superintendent detect mistakes in the drawings.

Information coordination problems amongst consultants were another recurring theme. Because of the complexity of the building, especially in terms of mechanical equipment, a large number of drawings was required. Design conflicts were often encountered. Computer aided design was not used by the consultants.

The lowest priced subcontractor almost always was selected because of the tight budget of the owner. As a result, trades known for quality were often not selected due to the higher price they carried. Some trades had worked with the construction manager before, while others had not (e.g. forming). None of the trades, except the elevator subcontractor, involved union workers.

For the forming contractor, this was their first mid-rise project. All of their previous projects

were two-story apartment buildings. They underbid this project due to their lack of experience in estimating the complexity of institutional type buildings. Since they were losing money on the job, much tension arose between JCS and the forming contractor.

Weather had a significant impact on construction. For example, during the winter, special precautions were needed to prevent the water line from freezing. On one occasion, the finishing activity for the floor slab had to be stopped due to a frozen pipe. Exterior labour-intensive activities such as shovelling and cleanup tended to slow down in cold weather. In addition, heat was needed continuously to keep the dampness out so that the workers could install the interior finishing.

It was observed that the selection of key management personnel is important for a project to succeed. Under the management of the first project manager, with his lenient approach to the trades, the project schedule suffered and became longer and longer as the project proceeded. When a new project manager was assigned, a new approach was used. The project schedule was refined and controlled in a professional manner resulting in a earlier project finish date for the project.

JCS personnel were very safety conscious. During the author's on-site stay, there were times when workers were sent off the site because of their unwillingness to comply with WCB safety requirements. The construction safety officer gave warning notices to different subtradesmen for working unsafely (e.g. not willing to wear a safety helmet, no steel-toed shoes, and not wearing a harness when working outside the fencing area of a deck). It was observed that most workers were willing to comply with safety standards once a warning was issued. In one incident, due to the unwillingness of two workers to comply with the safety requirements, they were asked to get off the site immediately. This caused the whole crew to stop work and walk off the job site, resulting in the loss of half a day's work.

Undermanning was a problem source that appeared quite frequently. Although many people walked onto the site looking for work during working hours, most of them were inexperienced workers and only suitable for general labouring type work. Trades that experienced frequent undermanning were mechanical (plumbing) in the earlier stage and in-floor heating. Several days were lost due to insufficient manpower on site. At the end of the study period, most of the trades that suffered under-manning had hired additional workers.

It was also observed that time was needed for workers to adapt to new technology and construction methods. A slow learning curve phenomenon was noticed on site. For example, the in-floor heating, which used metal strips instead of wire mesh to hold rubber heating tubes onto the floors, involved a learning curve effect. The metal strips, at first, could not hold the tubes onto the floor properly. Although it presented a cash saving for the owner, delays were encountered in the first slab level. After considerable practice, and as more workers were hired and more equipment (e.g. pin-guns) was purchased, productivity finally rose to an acceptable level.

Overall, according to the superintendent, the morale among the work force was high. They were highly motivated, and pride could be felt when they completed their work within the confines of a tight schedule. There was competition in terms of speed and quality amongst the trades at the site.

Security was also a problem at the site. The project suffered many break-ins which resulted in the loss of materials, tools and equipment. Reports to the police and insurance companies took up valuable time of management personnel. After suffering many break-ins, the superintendent hired a security guard to monitor the site during off-work hours.

2.3 USEFULNESS OF THE DATA COLLECTED

Using the daily site system offers many advantages. Analysis of the daily site data helped the project manager to evaluate performance of the project. Problem sources organized in a structured framework permit easy retrieval for legal documentation and reference. Documenting activity progress, problems encountered with activities and environment, site and work force conditions is very valuable when preparing claims.

Generally, site data are not gathered and organized in a logical fashion. Information and experience from a project usually remain as heuristic and seldom documented knowledge. Often, people find that problem sources have happened repetitively, only too late in time. If a pattern of problem sources can be detected early, corrective actions can usually be initiated to limit their impact. Knowledge gained from a project, when incorporated in an expert system, can be used again for future projects. Knowledge can be analyzed and formalized in a way that lends itself to heuristic forms of problem solving.

Nevertheless, some disadvantages accompany such a system. A major drawback is the amount of effort needed to collect reliable daily site data. For instance, the physical activity start and finish dates are sometimes difficult to determine. Often, a sub-contractor found design conflicts in a small part of his work. He would tell the project manager, complete what could be done on a floor, and go onto the next level. When the clarification came in later, he would then go back and finish the floor. Thus, the finish date for this activity was not firm since the activity was not finished; however, the successor activity could be started since most of the work for the predecessor activity had been done. To resolve this problem, the author frequently conferred with the superintendent regarding the progress of individual activities. I noted down the date which the superintendent indicated as the start of the successor activity

and marked that date as the finish date for the previous activity. Final completion of the predecessor activity, when design conflicts were resolved, would then be noted in the daily site system.

Prior to the study period, the superintendent used a free format report for the daily site report and chose not to follow its general format. Many times, he neglected to record information such as the skill level of the sub-trades, their overtime, etc.. Moreover, as stated previously, the original schedule was brief and had not been updated to reflect the on-going schedule of the project. Thus, the superintendent, when completing the daily site report, frequently needed to cross out many of the activities listed, since they were either already completed or were not in the current time window. Other on-going activities had to be penned in. Thus, these changes made the schedule very difficult to update prior to the study period.

As stated previously, for a sizeable project, it is difficult to maintain a complete mental image of the status of the project and hence record it on a daily site form. For example, during the study period, many tradesmen were on site. Since they were usually not static in one location, determining an accurate work force count was not very easy. Moreover, an accurate inventory of materials and procurement for the trades was difficult to determine.

2.3.1 ADDITIONAL PROBLEM SOURCES

A total of 15 problem sources were examined in this thesis; 7 from Fayek's work plus 8 new ones. The total list of problem sources used at site is shown in Table 2.1 (and on the bottom of the daily site form), and the new ones added to the automated analysis are flagged.

Table 2.1 Activity Problem Source List

1*.	Conflicting information
2*.	Construction error
3*.	Delay in awarding contract
4*.	Drawing error
5*.	Layout error
6*.	Low moral/motivation in worker(s)
7*.	Site not ready/available
8*.	Skill too low
9.	Too much precipitation
10.	Drawings insufficient/incomplete
11.	Undermanning
12.	Rework (workmanship)
13.	Inadequate external access
14.	Poor ground conditions
15.	Unanticipated utilities

The selection of the eight new problem sources was done using the following procedure:

1. The complete set of problem sources identified to date (see figure 2.2), minus the seven which the prototype system can already analyze, were presented to the experts. Each problem source category was discussed with the experts one at a time to minimize confusion.
2. The experts were asked to rank the problem sources under each category according to the amount of impact they experienced on previous projects.
3. The top two problem sources under each problem source category were then selected for possible

treatment. The elements of this set of eighteen problem sources were then ranked in order of importance.

4. From this ordered list, I selected the top eight problem sources as the additional problem sources for the thesis.

2.3.2 CORRECTIVE ACTIONS

New corrective actions were added to the list of existing corrective actions (see Table 2.2). They were obtained using the following procedure:

1. The original corrective action set was first presented to the experts for review. It was of particular interest to pinpoint the corrective actions which the experts believed they would never apply on a construction project or which were redundant with others. These actions were eliminated from the corrective action set. Examples include combining corrective actions "pursue a project time extension for unreasonable delay" and "request a time extension from the Owner for unanticipated utilities" into a single corrective action "pursue a project time extension for unreasonable delay beyond contact control" and modifying corrective action "open a claim for acceleration" to more specific "open a claim for acceleration at owner request", etc..
2. The 15 problem sources identified in Table 2.1 were presented to the experts again. Selective sets of corrective actions for these problem sources were created by the author prior to the discussion with the experts. I formulated the corrective action sets by using the literature and drawing on observations I made at the site. An attempt was made to formulate corrective actions to focus on specific problems but which are applicable to the same problem source on more than one project.
3. Each list of corrective actions was presented to the experts for their comments. I asked them to

view the information from a general point of view and not limit themselves to a specific project. Questions like "what would you do if you encountered this [problem source]?" were asked to improve the brainstorming sessions so that a complete set of corrective actions for each problem sources was created. New corrective actions elicited from the experts were added to each corrective action set.

Due to the complexity of this project, the management team personnel were preoccupied with the project and did not make significant contributions during the discussion sessions. Many times I attempted to arrange meetings with the experts, but achieved only limited success. Moreover, it proved to be difficult to document construction knowledge in a codified format. There is not a clear boundary of what one should and should not do in a situation. Seemingly, the range of corrective actions that management can pursue are quite limited in scope. The trick seems to be to identify the condition variables that make the selection of one action more appropriate than another. See Chapter 3 for dealing with the formulation of rules to select corrective actions.

4. The generated sets of corrective actions were combined into a global corrective action set. Redundant corrective actions were eliminated. All corrective actions were categorized under relevant headings.

5. Since there was a great emphasis on management, I refined this corrective action set and broke the "Management" category into subgroups of "On-site Management" and "Off-site Management". On-site management refers to those corrective actions which can be implemented directly at the field, e.g. improve supervision, purchase/rent equipment, etc.. Similarly, off-site management deals with actions by head office personnel, subcontractors, and suppliers. Corrective actions such as "submit letter of intent", "request information from architect and/or consultant ASAP", etc. are grouped under this category.

6. The complete list of corrective actions was then presented to the experts to check for completeness and appropriateness. Few changes were made.

Table 2.2 Activity Corrective Action List

0.0	**Do Nothing (Default)**
1.0	**ENVIRONMENT**
1.1	Provide a protected environment or shelter.
1.2	Postpone the activity to a time window with better anticipated weather conditions.
1.3*	Try to improve working conditions.
2.0	**WORK FORCE**
2.1	Seek additional tradesmen and allocate them to activity XXYYZZ.
2.2	Reallocate manpower from preferably a buffer or non-critical activity (XXSSTT) to activity XXYYZZ.
2.3*	Upgrade untrained personnel to trained personnel.
2.4*	Discuss with subtrade foreman workforce performance.

2.5*	If low motivation is exhibited by specific crew members, lay off unproductive workers and seek new ones.
2.6*	When workers are idle, reroute manpower to other activities to prevent severe manpower loss.
2.7*	Seek alternative subcontractor if possible.
2.8*	Perform work with own forces and backcharge subtrade.
2.9*	Hire more experienced workers to lead inexperienced workers.
2.10*	Reassign inexperienced workers to activities which do not require extensive skills.
2.11*	Hire experienced workers and substitute for inexperienced workers.
3.0	**CONSTRUCTION METHODS**
3.1	Conduct more on-site soil investigations.
3.2*	Where appropriate, use extra support or shoring to alleviate poor ground conditions.
3.3*	Seek possible alternative designs to save time, i.e. prefabricate beam and column forms in shop vs. free form.
3.4	Use an alternate construction method.
3.5*	To save time, use more equipment and less labour intensive construction method if budget and/or site conditions permit.

4.0	**ON-SITE MANAGEMENT**
4.1	Postpone the activity.
4.2	Do secondary work on the activity.
4.3	Increase the remaining duration of the activity.
4.4	Postpone interfering buffer or non-critical activities.
4.5	Investigate resequencing of remaining work.
4.6	Employ staggered shifts for interfering trades (trade stacking).
4.7	Investigate use of scheduled overtime.
4.8	Increase or improve supervision.
4.09	Reallocate tools/equipment from preferably a buffer or non- critical activity to a critical one.
4.10	Purchase or rent backup equipment/tools.
4.11	Use alternate routes of access.
4.12	Monitor the activity closely.
4.13*	Change follow-up layouts so error can be absorbed.
4.14*	Correct construction error at site immediately if possible.
4.15*	Discuss with/notify subtrade(s) of required changes in layout.

4.16*	Seek possible alternatives to accommodate changes if their details are likely to arrive too late to properly plan for.
4.17*	Reschedule procurements to a later date.
4.18*	Note down in daily report dates of information requested, conversations/verbal instructions, telephone calls etc.
4.19*	Commence work on a time and material basis.
4.20*	See if an alternative design can be used rather than performing remedial work to correct problems.
4.21*	Allocate time for rework to correct error.
4.22*	Videotape on-going construction sequences to pinpoint problems and solutions to improve performance. Use as part of targeted training program.
5.0	**OFF-SITE MANAGEMENT**
5.1	Improve subtrade management/coordination.
5.2	Employ a quality control program.
5.3	Establish improved equipment maintenance and management policies.
5.4	Make periodic visits to the fabricator's shop.
5.5	Identify alternate supplier(s).
5.6	Obtain street closure permit.

5.7	Reschedule the work to hours with less traffic.
5.8	Obtain from the City a location map of all utilities on the site.
5.9	Improve architect/engineer/consultant coordination.
5.10*	Contact relevant parties for correction and/or information.
5.11*	Call the architect to provide necessary information ASAP.
5.12*	Notify owner/project manager about the possibility of delay if the activity affected is a critical one.
5.13*	Submit letter of intent.
5.14*	Request information/clarification from architect and/or consultant(s) ASAP.
5.15*	Notify owner/project manager regarding the conflict in writing.
5.16*	Issue speedy memo to affected parties.
5.17*	Determine the impact of construction error on the project; if critical, seek additional trade/workers for rework.
6.0	**CONTRACT REMEDIES**
6.1*	Pursue a project time extension for unreasonable delay beyond the contractor's control.
6.2	Notify the Owner under a contract clause for unexpected conditions (ground conditions, utilities).

6.3*	If award of the contract is delayed, ask if the owner will pay for acceleration once the contract is awarded.
7.0	**PROTECTIVE ACTIONS**
7.1	Issue a memo to the Owner to request decision(s).
7.2	Issue a memo to the party concerned to request drawing completion.
7.3	Open a delay claim.
7.4	Open an extra work order.
7.5*	Open a claim for directed acceleration.
7.6	Open a backcharge to a subtrade or supplier for delay.
7.7	Open a backcharge to a subtrade or supplier for extra work.
7.8	Open a backcharge to a subtrade or supplier for acceleration.
7.9	Issue a memo to the supplier or fabricator requesting correction(s).
7.10	Notify the City of unanticipated utilities.
7.11	Open a claim for conditions not covered by the contract.
8.0	**MATERIALS**
8.1	Explore use of admixtures for concrete

2.4 GRAPHICAL REPRESENTATION OF DAILY SITE DATA

There is an old saying that "a picture is worth a thousand words". It is possible to have too much raw data, precluding the decision-maker from drawing meaningful conclusions. When expressing information in text form, one wants to select only the most important data for presentation. Unlike graphical displays, text and numerical tables cannot be scanned easily to obtain information. Many times, negative outcomes happen due to the project managers' inability to interpret the data in time. The use of graphics for reviewing daily site data could help simplify the analysis process and allow the user the flexibility to explore relationships or correlations amongst data items.

Roth and Hendrickson (1991) described the development of automatic graphics presentation systems. Since users of project management systems have different preferences for graphical formats and different information-seeking goals, the ability to select from a range of presentation techniques to represent data and to integrate them in a simple picture is vital.

There is a growing literature which addresses graphics representation. Roth et al. (1991) presented an application-independent graphics presentation system which utilizes graphics and natural language as components of automatic explanation. The system combines both text and graphics for its explanations, and therefore serves as a vehicle for exploring the interaction between these two modes of presentation. The goal of the system is to eliminate the need for end-users and application programmers to specify, design, and arrange a display each time output is needed for a project. Mackinlay (1986, 1991) developed an application-independent presentation tool that automatically designs effective graphical presentations of relational information. He stated that expressiveness and effectiveness are two crucial terms in graphics representation. Expressiveness criteria determine whether a graphical language can express the desired information. Effectiveness criteria determine whether a graphical language can exploit

the capabilities of the output medium and the human visual system.

The objective here is not to recreate these systems but to focus on the kinds of graphical images that might prove to be useful for construction management personnel. Thus, the effectiveness of graphical representations is the objective we seek here.

Some daily site data graphics have already been implemented in the research version of REPCON to support this thesis work. Some of the graphical images programmed were selected based on discussions with the project manager and the superintendent, while other modes of representation were generated internally and/or from the literature. Ultimately, an ideal situation would be to develop a flexible system which allows the user to select his/her x-axis and y-axis for the graph freely.

Split screen graphics can be helpful to make comparisons or explore correlations amongst data items. For example, a comparison between two histograms, with number of supervisors on top and amount of labour allocated on bottom, would help a project manager realize whether sufficient supervision has been assigned by each trade. See Figure 2.5 for a representation of this data for the project studied. Similarly, a dual screen of precipitation data on top and total lost time for an activity within a time window due to too much precipitation would indicate to a project manager whether special precautions should be taken for weather protection or extensions sought under relevant provisions of the contract. Aligned bar graphs can be used to display different information for the same data set. For example, time lost, man-hours lost and frequency of occurrence can be shown together for the problem source domain set. Figure 2.6 illustrates the problem sources encountered during the period of 1st December, 1992 and 14th January, 1992. Figure 2.7 and 2.8 illustrate the site conditions for the same period.

UBC CONSTRUCTION MANAGEMENT LAB
File Used: D \REP200\PROJ31\WTROUT
Report Period 01DEC92 - 14JAN93

Page 1

LEGEND

Trout Lake Manor - In Details (new Repcon)

Daily Site Graphics

REPCON™
Report Date 13DEC93
Report Time 15.35.11
Revision Number 0

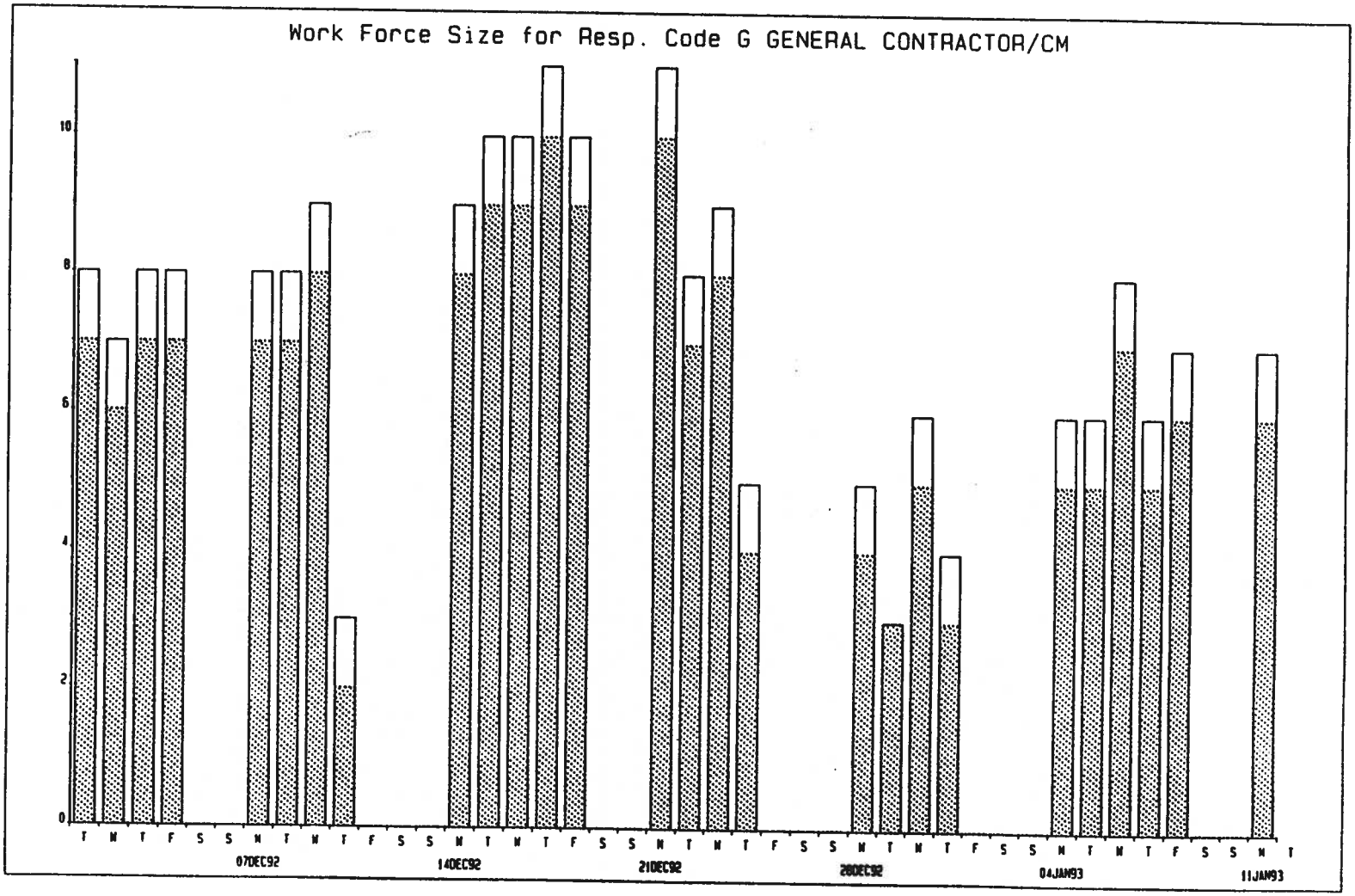

Figure 2.5 Bar graphs of work force data for General Contractor

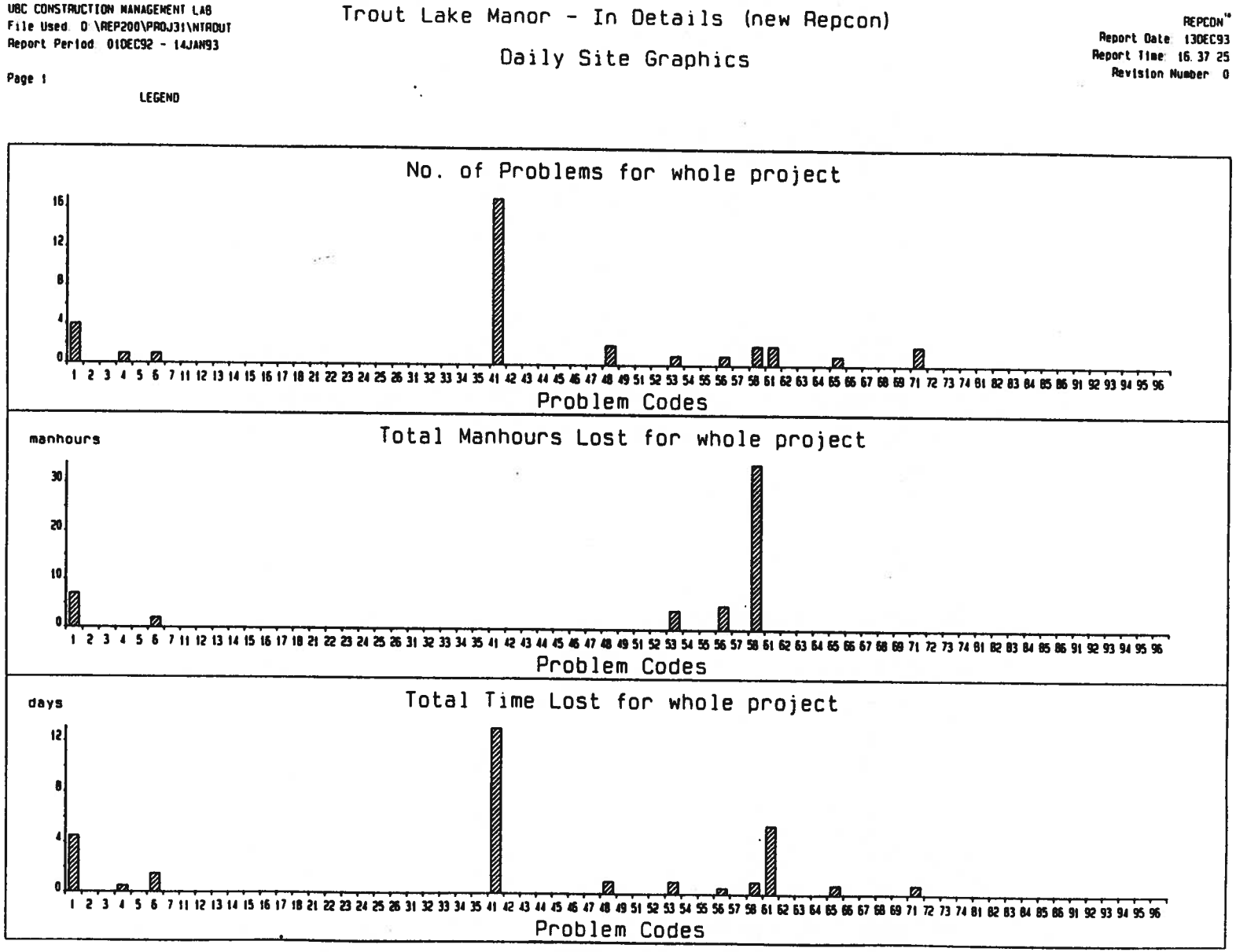

Figure 2.6 Split screen graphs for problem sources, total manhour lost and total time lost

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LEGEND

Trout Lake Manor - In Details (new Repcon)

Daily Site Graphics

REPCON™
Report Date 13DEC93
Report Time 15 31 17
Revision Number 0

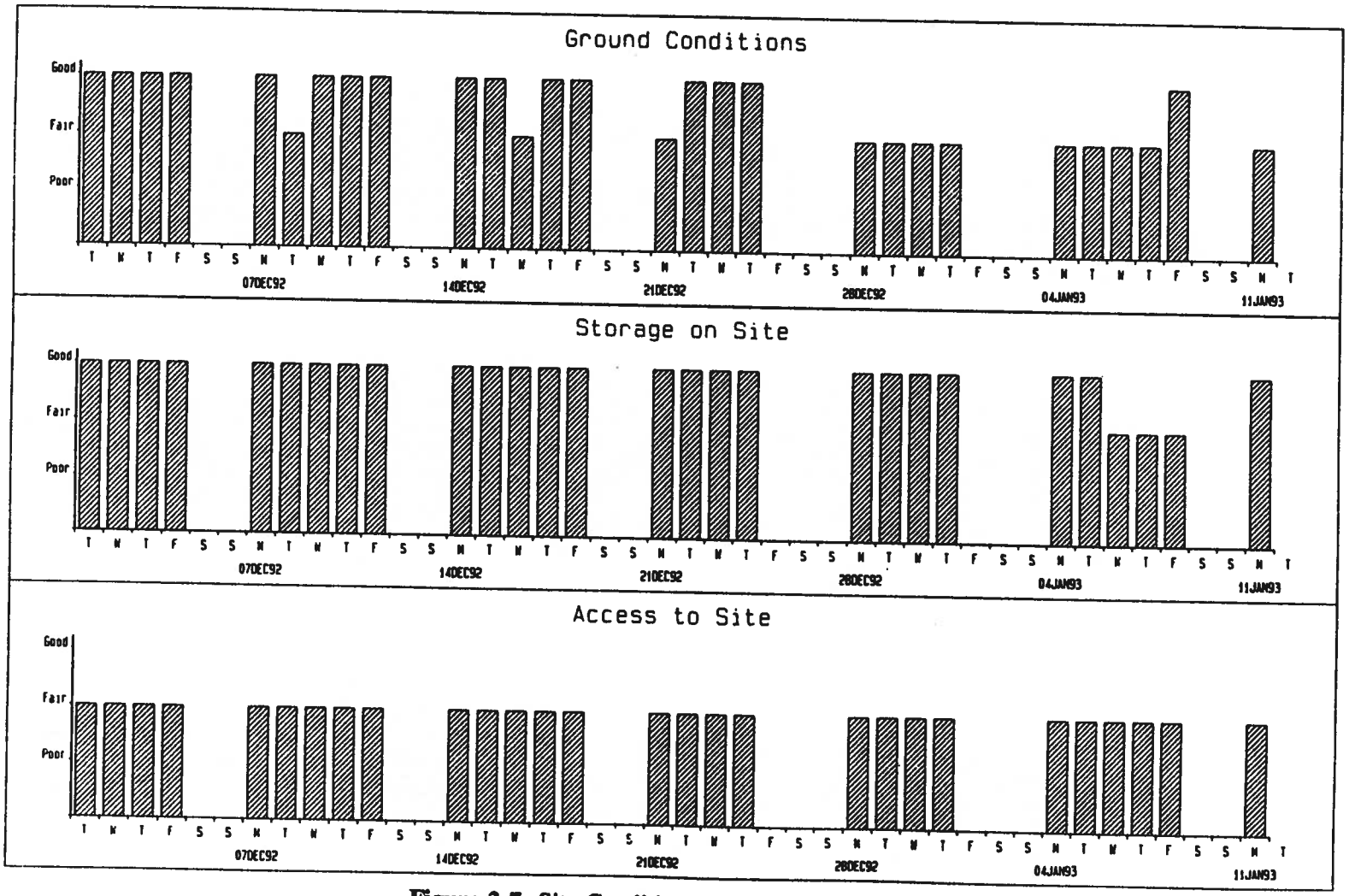

Figure 2.7 Site Conditions (1) for Case Study

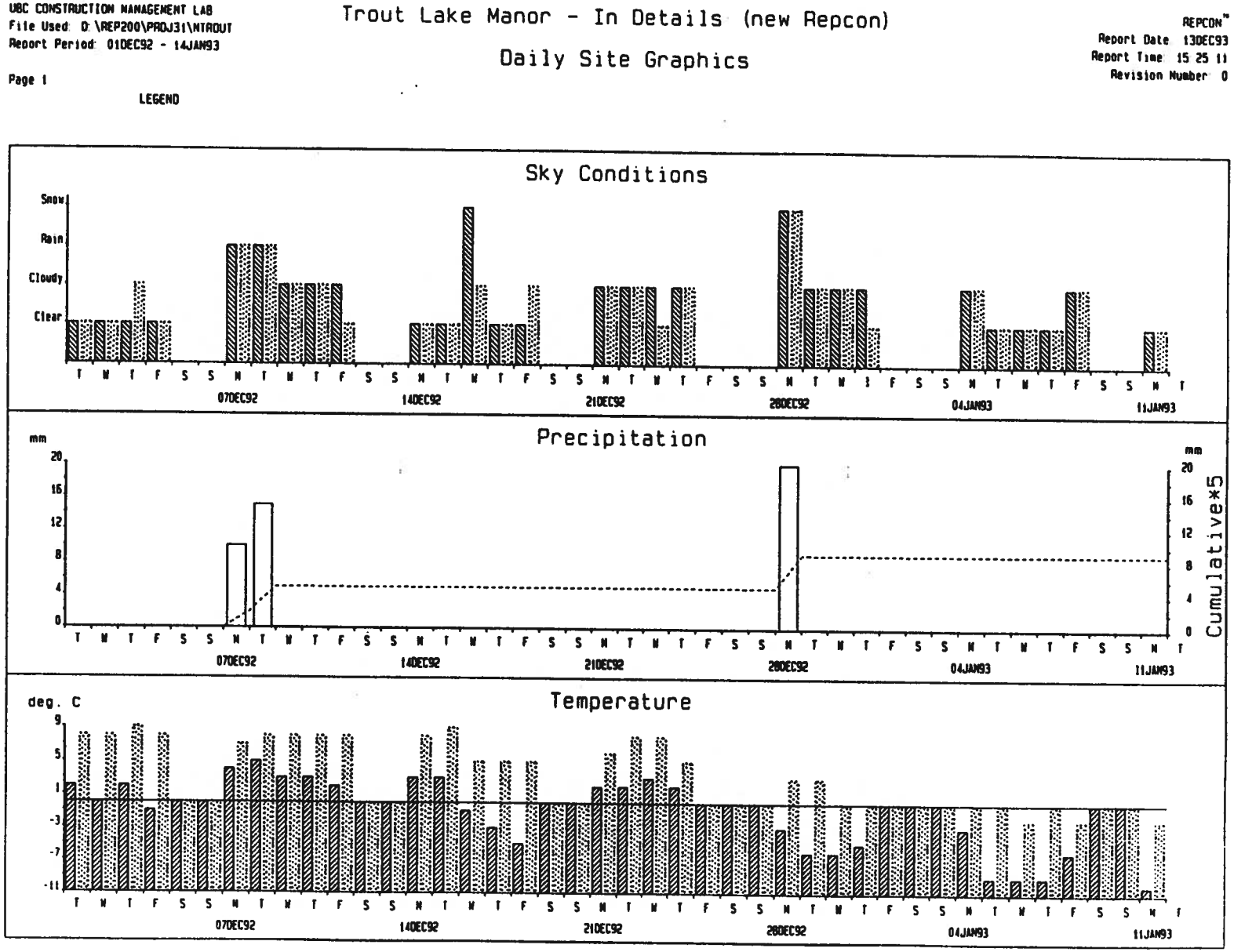

Figure 2.8 Site Conditions (2) for Case Study

A dual screen graphic of site conditions versus problem source frequency and/or time lost would indicate possible correlations between the two factors and may suggest the need for initiating corrective actions. This particular superposition of graphs is not supported in the research system.

The following graphical representation capabilities were incorporated into the daily site system.

1. Job Conditions / Activity Status

For a specific time window, we can superimpose up to three of the following graphs at a time:

Sky conditions (AM, PM)

Precipitation

Temperature (High, Low)

Wind Speed

Ground Conditions (Good, Fair, Poor)

Storage on Site (Good, Fair, Poor)

Access to Site (Good, Fair, Poor)

Activity status

The foregoing are all plotted versus time. For activity status, the information is shown only for a single activity at a time.

2. Work Force

For a specific time window, the following work force data can be plotted for a single trade:

Work force size

Overtime Hours

Skill level (of individual responsibility code)

Turn over (of individual responsibility code only)

At the project level, only the first two views can be plotted.

3. Problems

The items listed below can be plotted against problem source for a specified time window and four levels of detail: by activity location, by activity code, by responsibility code, and by whole project.

Number of Problems

Total Man-hours lost

Total Time Lost

Frequency of Problems

Percentile of Man-hours Lost

Percentile of Time Lost

3-D Graphics

Three dimensional representations of daily site data could be of significant value to project management personnel, as they would help identify patterns or pockets of problems. Examples of such graphs include the distribution of problems (or their consequences) versus time or location (Figure 2.9).

A split screen format which synthesizes two and three dimensional views would also enhance the evaluation of the project. One recommendation is a 3-D graph on one side together with three smaller 2-D graphs, representing the relationships of the three axis, on the other side. An example is shown in Figure 2.10.

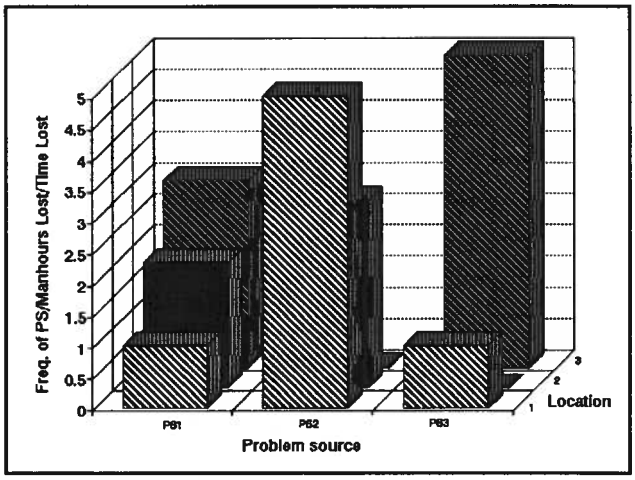

Figure 2.9 Sample 3D Graph

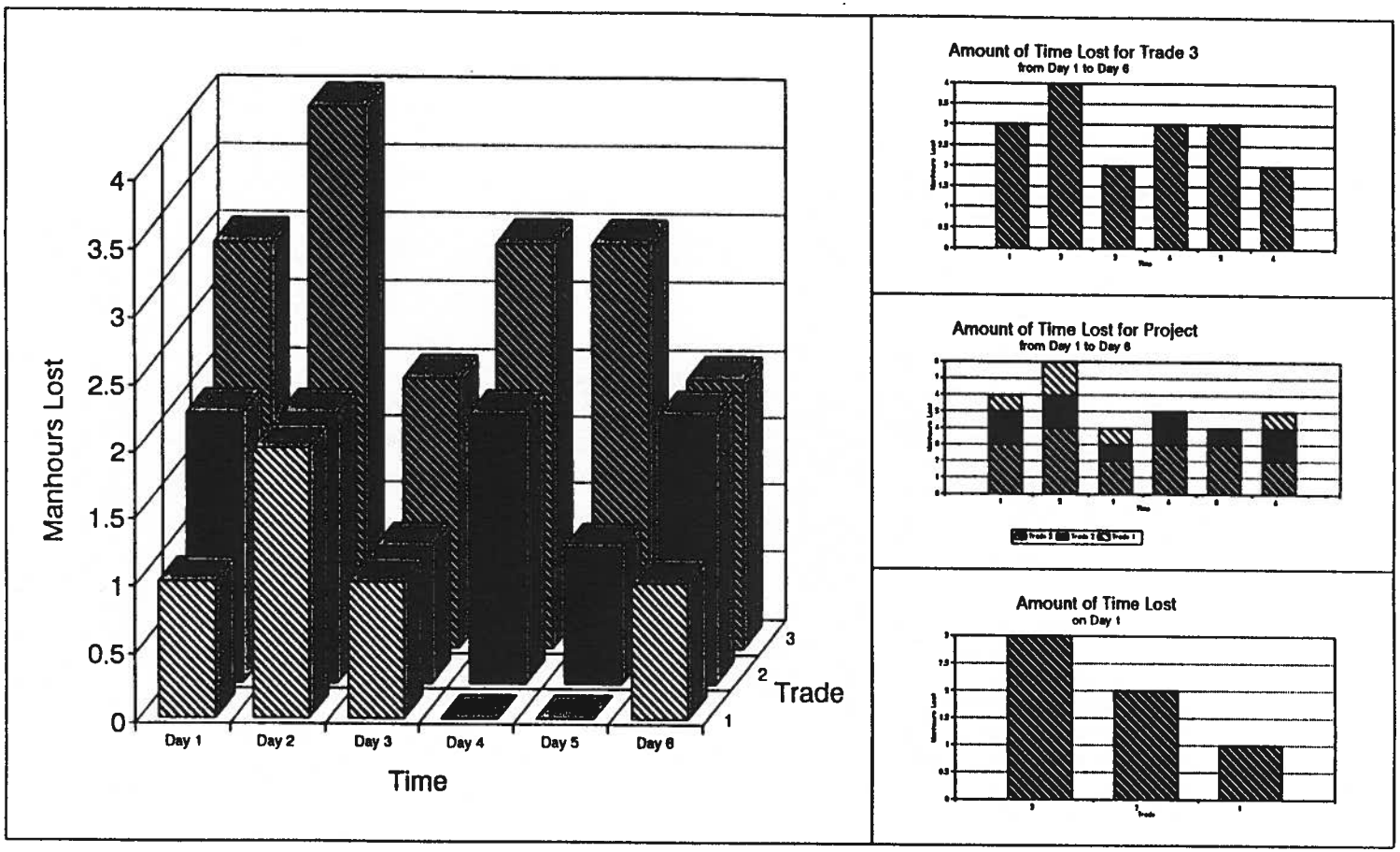

Figure 2.10 Sample 3D split screen graphs

CHAPTER 3.0 HIGHER LEVEL LOGIC

3.1 BACKGROUND

A major objective of this thesis is to develop the capability to analyze the data recorded against individual activities in order to be able to view it from a more global perspective. Problems may occur individually at the activity level; however, when activities are analyzed together as a group, significant patterns may be observed. Currently, the data interpretation system in REPCON (Fayek 1992) works on an activity-by-activity basis, with an activity being defined for analysis purposes as a single location of a multi-location activity. Each activity and problem source are treated separately. The corrective actions suggested for one problem source are independent of the results obtained for other problem sources for the same activity. Given a system potential of ninety problem sources and considering a project with two hundred activities, many of which could be multi-location activities, the volume of corrective actions generated is potentially massive. A project manager may find that some of the suggested corrective actions contradict each other, and consequently, they may not be very useful. Thus, a schema to integrate all problem sources for a given activity to produce one compatible set of corrective actions is sought.

Dubois and Prade (1993) stated that in their expert system, "partial conclusions obtained from different rules whose conclusions pertain to the same variable, have to be combined into a global conclusion. This combination step raises difficult problems: reinforcement or not in case of converging conclusions, synthesis of (partially) conflicting conclusions, preference of conclusions obtained by the most specific rules,... More generally it may be necessary to process several rules together in order to

take into account dependencies and imprecision of the input facts." Thus, there is a need for a schema to combine different problem sources and corrective actions when information is accumulated and presented at different levels of aggregation.

In addition, we seek to examine patterns of problem sources across all of the activities of a single trade as well as across all trades for a given time window. Consideration of the problem sources recorded and corrective actions initiated during a previous time frame when selecting corrective actions for the current time frame is left for future work.

A number of assumptions have guided the work. They are:

1. There is a commonality of problem sources amongst projects (e.g. undermanning). Thus, it should be possible to compile a comprehensive list of problem sources which is applicable to a broad range of projects or, at the very least, to a specific class of projects (e.g. high-rise residential projects). Clearly, there are problem sources that appear on an exceptional basis. For example, damage by war can be a significant problem source for construction projects in politically unstable countries. Such problem sources can be treated on an one-off basis.
2. Knowledge and lessons learnt from one project can be treated as experience and used on future projects. Heuristic knowledge, as noted from chapter 2, is difficult to formulate. However, as demonstrated in the literature, knowledge is documentable. Systems like MYCIN (Shortliffe, 1976), MASON (Hendrickson et al. 1987), etc. are just a few of the many successful examples of knowledge collection and documentation.
3. There exists, at least on a partial basis, a set of corrective actions that spans most projects and which responds to the list of problem sources. The selection of any one of these actions is

conditional on prevailing site conditions and project characteristics and also possibly on management style. The case study presented in the previous chapter suggested that for a given problem source, there are only a small number of corrective actions that management can initiate. For example, for the problem source under-manning, depending on project situations, one can hire more workers, upgrade the workforce, allocate more workers from buffer activities, etc. to cope with this situation. In addition, this problem source is universal and could appear on any construction site.

4. The base strengths that link problem sources with activity attributes are similar from one project to the next. This allows us to use the rule base on multiple projects (although some allowance should be made for editing the strengths which link problem sources and project conditions with corrective actions).

5. The basic reasoning schema developed by Fayek (1992) provides a satisfactory starting point for reasoning about corrective actions for individual problem sources at the activity level. Extensions that relate directly to her work include additions to the problem source list, additional and refined corrective actions, normalization of the strengths suggested for the corrective actions, and an upgraded inference engine that can handle both forward and backward chaining. This latter improvement allows us to employ more complex rules.

   Additionally, we have used only her schema A (see chapter 1), but with the added flexibility that the user can set the criterion to be used in the analysis - frequency of problem source, man-hours lost or time lost.

6. The compatibility factors that measure the conflict or reinforcement between corrective actions on a pair-wise basis are invariant for different problem sources and are independent of different combinations of corrective actions.

7. The standard strengths that link problem sources with activity attributes are the same for trade

and project attributes. See Appendix A for the linking values used for the examples in this thesis.

8. We seek an analysis schema that does not require feedback from the user during the analysis process. In particular, no intermediate assessments of the relative desirability of one corrective action over another is required, although it would be desirable. The reasons for this approach are that the amount of feedback required could be considerable, and the analysis cycles could be lengthened unduly. A consequence of this assumption is that it is not possible to optimize the reductions of the corrective action set.

3.2 BUILDING BLOCKS USED FOR HIGHER LEVEL ROUTINE

An attempt has been made to develop a schema that is applicable to three higher levels of analysis:

- integrating across all corrective actions for all problem sources for an activity;
- integrating across all problem sources for all activities of each trade; and
- integrating across all problem sources for all activities of all trades.

No attempt has been made in the current work to detect patterns of problems amongst an activity's location set. This could be important for being able to take preventative actions, such as adjusting the duration of remaining locations.

Building blocks developed as part of the task of formulating a higher level analysis schema are described below.

Dispersion Index

One issue in our analysis schema is how to distinguish a problem source that is very localized from one that is widely spread. Our hypothesis is that problem sources that occur at more than one location and/or for more than one activity may be more damaging than a problem that reoccurs for a single activity at a single location. To assist in identifying such situations, we introduce the concept of dispersion index (DI). The dispersion index is defined as:

$$DI = \frac{Number\ of\ unique\ appearances\ of\ a\ problem\ source}{Number\ of\ active\ activities} \qquad (3.1)$$

We start by counting the number of locations of all activities active in the time window under consideration. This is equal to the number of active activities which is the denominator in the previous expression. We then count the incidence of problems. A problem that occurs at a single location of an activity is counted only once, no matter how many times it occurs for that activity at that location. For example, if a problem source happens five times at one location of one activity, of which the culpable trade has a total of 20 different activities (locations) active, then the DI for this problem source would still be 1/20. On the other hand, if a problem source happens five times at five different locations, of which the trade has a total of 20 different activities, then the DI for this problem source would be 5/20.

Thus, from the above-mentioned example, it can be noted that $0 \leq DI \leq 1$. A value of zero indicates that the problem source at hand never occurs; on the other hand, a value of one denotes that every activity at every location has at least one occurrence of the problem source. Using this index, the distinction between a very localized problem and a widely spread problem can be accounted for.

Compatibility Factor

Let CF_{ij} be a measure of the compatibility between two corrective actions Z_i and Z_j. We have defined CF_{ij} to lie in the range $-1 \leq CF_{ij} \leq 1$, as shown in Figure 3.1. This notion of compatibility is similar in many respects to the concept of correlation between random variables. The value -1 illustrates that the two corrective actions are TOTALLY OPPOSITE to each other; the selection of one will substantially conflict with the other from the list of corrective actions and their simultaneous application is likely to nullify their potential effectiveness. On the other hand, the factor +1 represents complete compatibility of two corrective actions, and taken together, they reinforce each other. Doing both of them would enhance the effectiveness of the corrective actions for the project sources, although one cannot assert that the effect of the actions would be greater than the sum of the parts (e.g. multiplicative). Independent actions (e.g. $CF_{ij} = 0$) are assumed to be only additive in their effect.

Matrix CF
(Assumed symmetrical)

	Z_1	Z_2	Z_3	•	•	•
Z_1	1	1	-1			
Z_2	1	1	0			
Z_3	-1	0	1			
•						
•						
•						

Figure 3.1 Compatibility Matrix

In reality, the range of the CF could be any number. To simplify the elicitation task, CF is limited to the values -1, 0 or 1 in this thesis, rather than taking on any value in the range -1 to 1. Future work should address the reasonableness of using fractional values and the burden of eliciting CF_{ij} values.

An example compatibility factor matrix is presented in Table 3.1 for the first three corrective actions listed in Table 2.2. These values were established in discussion with Dr. Russell, and have not been reviewed by industry personnel. After estimating values of the three levels of compatibility matrix

Table 3.1 Sample activity level compatibility factor matrix

Corrective action 1		Corrective action 2		Coefficient
1.1	Provide a protected environment or shelter.	9.1	Do nothing.	-1.0
1.2	Postpone the activity to a time window with better anticipated weather conditions.	1.3	Try to improve working conditions.	-1.0
		4.1	Postpone the activity.	1.0
		4.4	Postpone interfering buffer or non-critical activity.	1.0
		4.5	Investigate resequencing of remaining work.	1.0
		4.17	Reschedule procurements to a later date.	1.0
		5.12	Notify owner/project manager about the possibility of delay.	1.0
		6.1	Pursue a project time extension for unreasonable delay beyond the contractor's control.	1.0
		7.11	Open a claim for conditions not covered by the contract.	1.0
		9.1	Do nothing.	-1.0
1.3	Try to improve working conditions.	3.5	To save time, use more equipment and less labour intensive construction method if budget and/or site conditions permit.	-1.0
		9.1	Do nothing.	-1.0

been reviewed by industry personnel. After estimating values of the three levels of compatibility matrix files, it is noted that there is not a significant number of -1 values, i.e. corrective action pairs with contradictions, amongst all the corrective actions. As a consequence, the corrective action set for an activity (trade or project) may not be reduced significantly using the process described later.

One major drawback in the formation of this matrix is the substantial effort required to elicit all of the compatibility linkings. From our limited experience to date, it would appear that many of the corrective actions are independent of one another. They neither conflict with nor reinforce each other. Thus, the default value of CF_{ij} is zero, easing the elicitation task.

Resolving Conflict Amongst Corrective Actions Using the Compatibility Matrix

We seek a process for reducing the corrective action set to minimize conflicts amongst the corrective actions recommended. This leads to a strengthening of the weights for some corrective actions and the elimination of others. This is similar to the many conflict resolution routines used in expert systems today. For example, in Hayes-Roth et al. (1983), a "consistency enforcer" is used to maintain a consistent representation of the emerging solution. The same literature also concluded that most expert systems use some kind of numerical adjustment scheme to determine the degree of belief in each potential decision. The scheme attempts to ensure that plausible conclusions are reached and inconsistent ones are avoided.

Other consistency enforcing schemes have been described in the literature. For example, Weiss et al. (1978) described a model-based medical consultation system. CASNET, the model described, is used by clinical decision-making for:

a. selecting and interpreting observations,

b. analyzing and resolving conflicts and contradictions in the observations,

c. selecting diagnostic and prognostic categories,

d. recommending treatments.

The described system utilizes forward and backward weighting schemes to determine the admissible pathway from one node to another. The test result which is held with greatest confidence is taken as the accepted result. If conflicting results are received with equal confidence, then the conflict is noted, and the status of the state of disease remains undetermined until additional results, with greater confidence, resolve the conflict.

It is also noted that in general, the overall effect of forward weight calculation is to increase the weights of those nodes resulting from confirmed nodes while decreasing those from denied nodes. On the other hand, the calculation of inverse weights is strongly influenced by evidence for the confirmation or denial of nodes. The weight of a node may be increased when its effects are confirmed. It is suggested that initially, a pathway may be an unlikely alternative, but after some testing it may become the only feasible pathway to a particular confirmed node. This results in increased weight assignments to the remaining causes of the confirmed node.

Such weighting schemes might suggest some insights for the selection of corrective actions as to minimize conflicts for the application described herein. However, I was unable to find in the literature a conflict resolution schema that was directly applicable to the problem of reducing the corrective action set to minimize conflicts. We therefore sought a metric or scalar whose properties we could exploit in order to determine which corrective action weights should be strengthened or weakened.

Let:

$$S = Z^T \, CF \, Z \tag{3.2}$$

be a scalar which measures the compatibility of a set of corrective actions: Z is a n-dimensional vector of normalized strengths of corrective actions (Z_i, i = 1, ..., n and $\Sigma \, Z_i = 1$), as recommended by the

expert system following the analysis of daily site records and CF is the compatibility matrix described previously. Some properties of S are:

(i). Its maximum value is 1. This can be achieved if all of the strength is assigned to a single corrective action. It is independent of the values assigned to the CF_{ij} (note: $CF_{ii} = 1$).

(ii). If all corrective actions reinforce each other (i.e. $CF_{ij} = 1$ for all i and j), then S also equals 1.

(iii). Suppose all corrective actions are recommended with equal weight i.e. $Z_i = 1/n$. Assume, further, that all corrective actions are independent so that CF = [I]. For this case,

$$S = \sum Z_i^2 = \frac{1}{n} \tag{3.3}$$

(iv). Also, when all $CF_{ij} = -1$ with $i \neq j$, then $S = -(n-2)/n$ which approaches -1 as n gets large.

It would appear then that if S is a measure of effectiveness, that individual corrective actions strengths should be reassigned to a single corrective action. In order to do this, however, we would require an assessment of the relative effectiveness of each corrective action for the problem sources at hand for prevailing project conditions. This would require intervention by the user, something we are trying to avoid. The Z_i represent the strengths with which a corrective action is recommended, based on project conditions, activity attributes, etc.. They are not a measure of relative effectiveness. Thus, we have no basis for reassigning Z_i to increase S (i.e. we cannot optimize the value of S). However, in the case of conflict between pairs of corrective actions, we can exploit the properties of S to reassign weights to increase the value of S. If there is not significant conflict between corrective actions (i.e. few $CF_{ij} = -1$), then the schema proposed will not result in much reduction in the corrective action set.

Our approach is as follows:

1. Expand $S = Z^T CF\ Z$, i.e.

$$[Z_1\ Z_2\ Z_3\ \ldots\ Z_n\ ] \begin{bmatrix} 1 & CF_{12} & CF_{13} & \ldots & CF_{1n} \\ CF_{21} & 1 & CF_{23} & \ldots & CF_{2n} \\ CF_{31} & CF_{32} & 1 & \ldots & CF_{3n} \\ \vdots & \vdots & & & \vdots \\ CF_{n1} & CF_{n2} & .. & .. & 1 \end{bmatrix} \begin{bmatrix} Z_1 \\ Z_2 \\ \vdots \\ Z_n \end{bmatrix}$$

as

$$S = Z_1(\sum Z_j CF_{1j}) + Z_2(\sum Z_j CF_{2j}) + \ldots + Z_n(\sum Z_j CF_{nj}) \qquad \textbf{(3.4)}$$

which can be written as

$$S = \sum Z_j\ \phi_j \qquad \textbf{(3.5)}$$

where

$$\phi_j = \sum Z_i\ CF_{ij} \qquad \textbf{(3.6)}$$

2. We are interested in the scalar value of ϕ_j. When the value of ϕ_j is less than zero, the associated value of Z_j should be driven to zero in order to increase S while reducing conflicts. The value assigned to Z_j should be reassigned to the corrective action k, which has the largest positive value of ϕ (or the least negative value if all $\phi < 0$) in order to maximize growth in S.
3. If there is more than one Z_k that has the largest positive ϕ_k, redistribute the value of Z_j equally to the Z with the same ϕ_k.
4. This reassignment process in steps 2 and 3 should be repeated until all ϕ_j are greater than or equal to zero.

One advantage of this approach is that the strengths assigned to the corrective action set remain normalized. The use of this schema for reassigning weights is demonstrated in an example at the end of

this chapter.

Additional check for corrective action "DO NOTHING"

After completing the aggregation schema for corrective actions, a corrective action "DO NOTHING", with a weight of 1.0, is assigned by default to those problem sources which associate with no corrective action due to lack of evidence. Thus, this "DO NOTHING" is different from the corrective action which resulted from either no time and manhours lost or just not enough time to act upon a problem source. A distinction between them is needed.

In coping with this situation, three distinctive "DO NOTHING's" are added. These corrective actions are more informative in explaining the causes of the corrective actions. The three "DO NOTHING"'s are:

(a) DO NOTHING - lack of evidence,

(b) DO NOTHING - no time or manhours lost,

(c) DO NOTHING - insufficient time to act on problem.

These corrective actions are then used in the aggregation routine and are treated as any other corrective actions for that level of analysis.

The priority of these three corrective actions is (a) < (b) < (c). Thus for example if a problem source has no time or man-hours lost and has no corrective actions due to lack of evidence, (b) will take precedence over (a) and be the only "DO NOTHING" for this problem source. Moreover, the corrective action "DO NOTHING" has a compatibility matrix coefficient of -1 linked between it and any other direct implementable actions.

Other building blocks for higher level routine

Other building blocks for analysis at the trade and project levels are discussed in more detail in sections 3.3.3 and 3.3.4. The basic ingredients are attributes (as seen later, trade and project level attributes can be derived from activity level attributes), total man-hours and time lost, a linkage between attributes, problem sources and corrective actions, expert system rules (described below), compatibility matrices and corrective action files. The analysis process performed at the trade and project levels is similar to the process used at the activity level.

Based on the work to date, the number of corrective actions at the higher levels of analysis is significantly less than at the activity level. This seems reasonable, as the prerogatives available to address problems are quite restricted, and generally relate to management actions dealing with key personnel, subtrades, etc..

3.3 GENERAL LAYOUT OF HIGHER LEVEL ANALYSES

This routine breaks the analysis process into several steps as follows:

a). Define a hierarchical analysis schema for the project.

b). Suggest corrective actions for each problem source for an activity.

c). Analyze and combine the corrective action sets for different problem sources of one activity.

d). Combine different problem sources for different activities for the same trade and suggest trade level corrective actions.

e). Combine and analyze different problem sources at the project level and suggest

project level corrective actions.

3.3.1 HIERARCHICAL ANALYSIS SCHEMA

A five level hierarchy is envisaged as part of a comprehensive system:

a). Individual problem source at the activity level.

b). All problem sources at the activity level.

c). All problem sources at the trade level.

d). All problem sources at the sub-project level.

e). All problem sources at the project level.

For our analysis scheme, we omit the subproject level. The simplified diagram that we used for the base of this thesis is shown in Figure 3.2. Nevertheless, the subproject level would be an essential ingredient for a system designed to accommodate large projects. As noted previously, an additional step could be inserted between (b) and (c) for the case of activities with multiple locations.

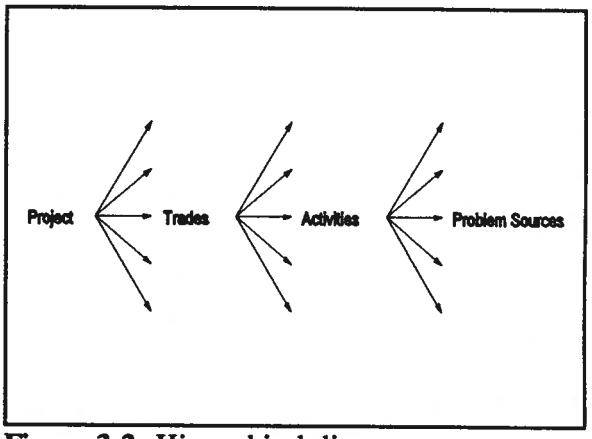

Figure 3.2 Hierarchical diagram

When we analyze a project, we start from the individual problem source level and proceed towards the project level. The first level has been treated by Fayek (1992) with the modifications as noted in section 3.1 and is not considered further here. The corrective actions suggested for an individual problem source are first checked for their compatibility with other actions and problem sources for the

same activity. When this is completed, a reduced corrective action set is suggested for the complete set of problem sources.

3.3.2 ACTIVITY LEVEL ROUTINE

Here, we present the steps involved in the activity level analysis, after corrective actions have been suggested for each problem source encountered. The routine utilizes a weighting schema and the compatibility matrix to combine all the corrective actions suggested for different problem sources at the activity level. Basically, the activity analysis can be separated into several modules as shown in Figure 3.3. All of the analysis is with respect to a user-specified time window.

Define the following notation.

Let:

i be the activity number i=1, ..., I

k be the problem source number k=1, ..., K

j be the corrective action number j=1, ..., J

$Z_{ik}(j)$ be the strength assigned to the j^{th} correction action for the i^{th} activity and k^{th} problem source from the first level of analysis.

W_{ik} be weight given to the k^{th} problem source for the i^{th} activity

CF_{mn} be the compatibility between corrective actions m and n (the notation CF_{ij} was used previously.)

To simplify the exposition at the activity level, we drop the subscript i. Moreover, keep in mind that our goal is to merge corrective actions across all problem sources.

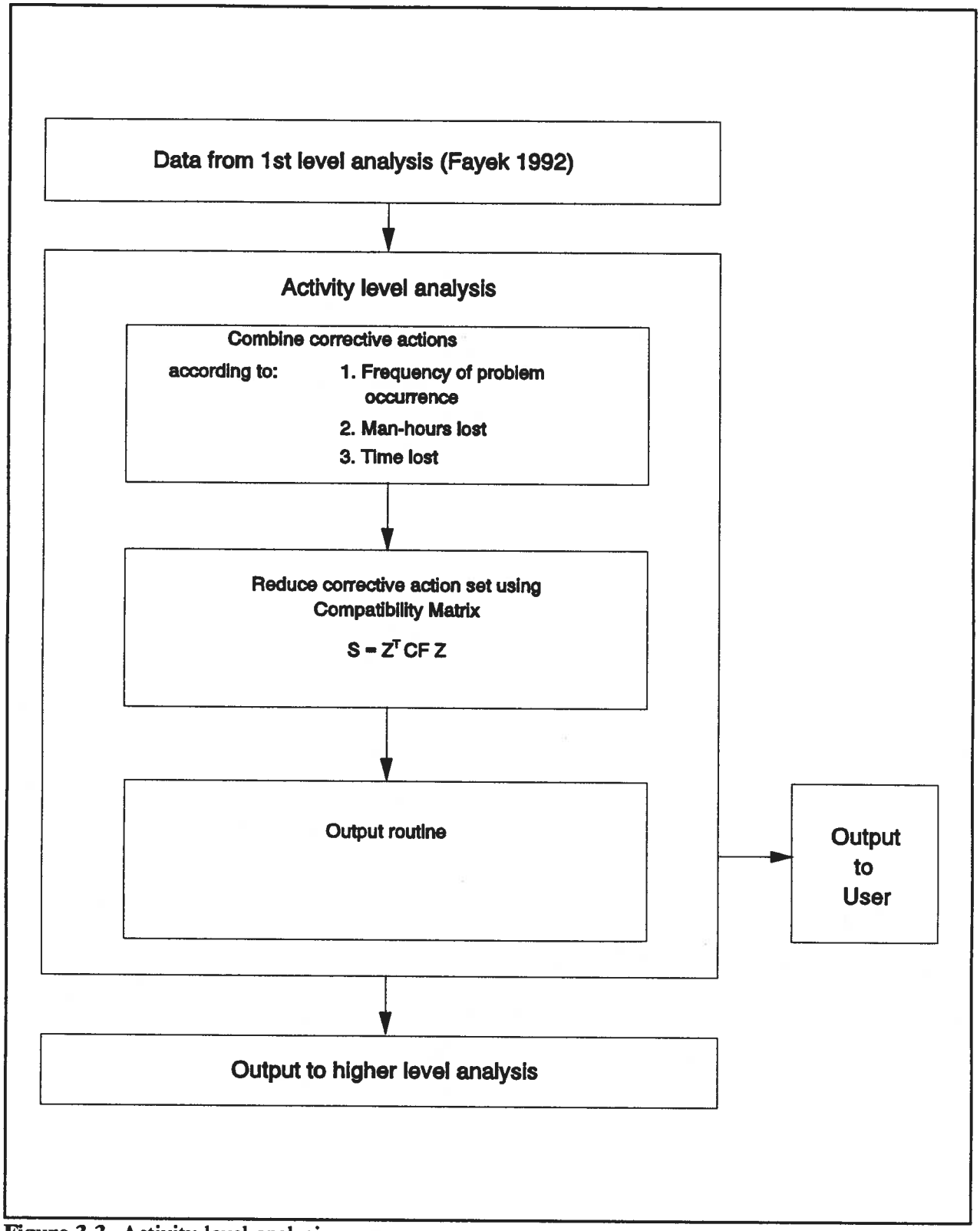

Figure 3.3 Activity level analysis

3.3.2.1 Weighting corrective actions

From the initial analysis, we have an adjusted vector $\underline{Z}_k$ of corrective action strengths for each problem source k that affected an activity - i.e. we have

$$\underline{Z}_k = \begin{bmatrix} Z_k(1) \\ Z_k(2) \\ \vdots \\ Z_k(J) \end{bmatrix} , \textit{for all } k,\ k = 1, \ldots, K \tag{3.7}$$

We seek to combine the corrective action vectors into one and then reduce the entries in the combined vector (i.e. the number having non-zero strengths) using the compatibility matrices between the various corrective actions.

1. We start by assigning a set of normalized weights to the problem sources to denote their relative importance. We consider three ways to determine the weights W_k; $k = 1, \ldots, K$, when $\sum W_k = 1$.

   (i) Weights are determined by frequency of occurrence of problem source.

$$W_k = \frac{\textit{number of occurrences of } k^{th} \textit{ problem source}}{\textit{Total number of occurrences of all problem sources}} \tag{3.8}$$

   (ii) Weights are determined by man-hours lost.

$$W_k = \frac{\textit{manhours lost due to } k^{th} \textit{ problem source}}{\textit{Total manhours lost from all problem sources}} \tag{3.9}$$

   (iii) Weights are determined by time lost.

$$W_k = \frac{\textit{time lost due to } k^{th} \textit{ problem source}}{\textit{Total time lost from all problem sources}} \tag{3.10}$$

2. Before considering the compatibility of corrective actions, we sum the vectors of corrective action strengths weighted by the importance of the problem source to obtain a single vector of corrective actions, $\underline{Z}$.

   i.e.

$$\underline{Z} = W_1 \begin{bmatrix} Z_1(1) \\ Z_1(2) \\ \vdots \\ Z_1(J) \end{bmatrix} + W_2 \begin{bmatrix} Z_2(1) \\ Z_2(2) \\ \vdots \\ Z_2(J) \end{bmatrix} + \ldots + W_K \begin{bmatrix} Z_K(1) \\ Z_K(2) \\ \vdots \\ Z_K(J) \end{bmatrix} \tag{3.11}$$

   Note that since $\underline{Z_k}$ is normalized and $\underline{W}$ is normalized, then $\underline{Z}$ is normalized.

3. We now seek to reduce the number of corrective actions selected by considering their pairwise compatibility. This reduction step uses the process described previously in section 3.2.

3.3.2.2 Run through Compatibility factors

Assume the activity compatibility matrix is created ahead of time. From the above weighting scheme of corrective actions, we have for the j^{th} corrective action a strength Z(j) i.e.

$$Z(j) = W_1 * Z_1(j) + W_2 * Z_2(j) + \ldots + W_K * Z_K(j) \tag{3.12}$$

1. Get all compatibility factors (CF_{ij}), where i and j are the corrective actions.
2. Utilizing the $S = Z^T CF\ Z$ reduction scheme described in Eqn. (3.4), we have

$$S = Z(1) * \sum_{j=1}^{J} Z(j) * CF_{1j} + Z(2) * \sum_{j=1}^{J} Z(j) * CF_{2j} + \ldots + Z(J) * \sum_{j=1}^{J} Z(j) * CF_{Jj} \qquad (3.13)$$

3. Let

$$\phi_n = \sum_{j=1}^{J} Z(j) * CF_{nj} \qquad (3.14)$$

4. We drive the value of Z(n) to zero when $\phi_n < 0$ and assign the weight of Z(n) to the Z(m) with the largest positive ϕ_m.

5. If none of the ϕ_n * Z(n) is less than zero, stop and exit the routine.

   If none of the ϕ_n is greater than zero, then pick the most negative ϕ_n and assign its Z(n) to the Z with least negative ϕ.

   If two or more ϕ_n's are equal and negative in value, reassign the one with the smallest Z(n) to the Z(j) with the largest positive ϕ_j.

   If two or more Z(j) have the same largest positive ϕ_j, reassign the strength(s) to the one with the largest Z(j).

   If two or more Z(j) have the same largest positive ϕ_j and value Z(j), distribute the strengths evenly amongst them.

   Otherwise, return to step 3.

3.3.2.3 Feedback to user

The system outputs the reduced set of corrective actions for this activity. The output also lists the new normalized strengths, along with the problem sources each corrective action originated from. Moreover, any untreated problem sources, i.e. no corrective actions selected, are also reported to the user.

3.3.3 Trade Level Routine

In the trade level analysis, the goal is to determine if a pattern of a problem source over the activities of a trade exists. It is asserted that additional emphasis should be placed on problem sources which appear over many locations of the same activity and/or over many activities and work locations of these activities. When the same problem source appears frequently across the trade's activities, it sends a signal to the decision-maker that there may be something wrong with one or more of the management of the trade, the design of the trade's work, site conditions for the trade, etc.. Thus, the trade's work should be examined more closely to determine if additional corrective actions over and above those identified at the activity level should be explored.

In developing an analysis routine for the trade and project levels, we have attempted to emulate the analysis process used at the activity level. In essence, at the trade level, we have merged all of the on-going activities of a trade for the time window specified into a single work package which is treated as an "activity" (similarly for the project level). We determine attributes for this activity as a function of the activities it represents, and call these trade attributes. Corrective actions sets are then suggested for each problem source, using the reasoning process used at the individual activity and problem source level, but with a different rule base and corrective action set. We then seek to merge the corrective action sets into one, taking account of the relative importance of the various problem sources (as measured by their consequences and dispersion) and their compatibility.

3.3.3.1 Trade Problem Source

For this thesis, problem sources treated to date are "Conflicting information", "Undermanning" and "Construction error" for the trade level analysis. These problem sources were selected based on the observations from the field study described in chapter 2.

3.3.3.2 Trade Corrective Action List

The corrective actions for the trade level analysis are shown in Table 3.2.

Table 3.2 Trade corrective action list

1.0	**Workforce**
1.01	Assign more men to the project.
1.02	Reduce workforce size.
1.03	Replace crew with a more experienced one.
1.04	Investigate alternate start of work day for crew.
1.05	Seek additional workmen for rework.
2.0	**Management**
2.01	Adopt a more stringent quality control program for this trade.
2.02	Discuss with subtrade its overall performance.
2.03	Acquire new subtrade.
2.04	Prepare delay claim.
2.05	Place special attention on activities for localized problem source.
2.06	Improve subtrade coordination.
2.07	Improve architect/engineer/project manager coordination.
2.08	Open extra work order since problem originated with architect/engineer.

3.3.3.3 Trade Level Analysis Schema

Let:

p be the trade number p= 1, ..., P

k be the trade problem source number k=1, ...,K

a be the trade attribute number a=1, ..., A

M_{kp} be the number of unique occurrences of problem source k for trade p

N_p be the number of active activities for trade p

$V_a(p)$ be value of trade attribute a for trade number p

W_{kp} be the weight for problem source k for trade p

The process is elaborated as follows:

(i) **Determine Trade Attributes**

The trade attribute set is the same as the activity attribute set, as shown in Table 3.3.

Table 3.3 Trade attributes

Sensitive to:	1. High precipitation 2. Low precipitation 3. High temperature 4. Low temperature 5. Humidity 6. Wind 7. Ground conditions 8. Storage on site 9. Site congestion 10. Internal access 11. External access
Characteristics:	12. Labour intensive 13. Equipment intensive 14. Buffer activity 15. Innovative Methods
Subject to:	16. Design changes 17. High inspection 18. Contract provision 19. Controlled environment 20. Low tolerance 21. Learning curve effects 22. Design complexity

Trade attributes are derived from the trade's activities that are active in the time window selected. Each

trade attribute is defined by:

$$V_a = \frac{Sum\ of\ the\ attribute\ values\ for\ all\ active\ activities}{Number\ of\ active\ activities\ for\ the\ trade} \qquad (3.16)$$

For example, if the trade has five activities in total, and each of their activities' attributes regarding the sensitivity to high precipitation is [1.0, 1.0, 0.5, 0.0, 0.5], then the trade attribute for high precipitation is obtained as:

$$(1.0+1.0+0.5+0.0+0.5)/5 = 0.60$$

In the calculation procedure, each location of a multi-location activity is considered as a separate activity; i.e. if an activity takes place at 5 work locations during the time window selected, its activity's attributes will be multiplied by the weight of 5 in calculating the trade attribute.

With the trade attributes defined, we calculate all $V_a(p)$ to obtain a matrix [V], in which each element $V_a(p)$ represents the attribute value for the a^{th} attribute, p^{th} trade as:

$$[V] = \begin{bmatrix} V_1(1) & V_1(2) & \dots & V_1(P) \\ V_2(1) & V_2(2) & \dots & V_2(P) \\ \vdots & \vdots & & \vdots \\ V_A(1) & V_A(2) & \dots & V_A(P) \end{bmatrix} \qquad (3.17)$$

Each column represents the trade attributes for each trade in the current window.

(ii) Determine Corrective Actions for Each Problem Source

Using the trade level attributes, trade level problem sources, expert rules, and corrective action set, trade level analysis can be performed to generate a set of suggested corrective actions for each problem source.

(1). Each $V_a(p)$ is linked up with the problem sources by the standard strengths S(X, V), defined at

the activity level. (Note the assumption that the linkage between attributes and problem sources is identical at the activity, trade and project levels.)

(2). T(V, Z) is the trade level rule base which links the trade attributes with the trade level corrective actions. All of the rules follow the general "IF-THEN" rule format, and focus on the attributes and performance of the various trades. Examples of trade level expert rules dealing with the problem source "Undermanning" are shown in Figure 3.4. These rules lead to different corrective actions; for example, the first rule in Figure 3.4 simply states that if the dispersion index is less than 0.3 (a localized problem at hand), then link the trade attribute 12 (labour intensive) with corrective action 1.1 (assign more men to the project) with a strength of 0.3*@DI. Similarly, the second rule states that if the current problem is undermanning, and if the dispersion index is greater than 0.7, and if less than 25% of the trade's activities are completed, then link trade attribute 12 (labour intensive) with trade corrective action 2.4 (acquire new subtrade from outside sources) with a strength of 1.0*@DI.

```
#rem second level rule for undermanning

#REM Define ag_strength v z w  (trade attribute, trade level corrective action, weighting
        of linkage)
#rem define current(problem, @)
#rem define trade(percent_remain_duration, @)
#rem define manpower(skill, @)
#rem define site(condition, @)

#If current(problem, Undermanning) and
     <(@DI, 0.3)
#then
       $ag_strength 12 1001 0.3*@DI
#end
#If current(problem, Undermanning) and
     >=(@DI, 0.7) and
    trade((percent_remain_duration,@B),  >=(@B, 75))
#then
       $ag_strength 12 2004 1.0*@DI
       #rem Acquire new trade
#end
```

Figure 3.4 Sample of Trade level expert rule

(iii) Determining Weights for Combining Corrective Actions

1. Compute dispersion index

As before, the dispersion index DI_{kp} is defined as:

$$DI_{kp} = \frac{M_{kp}}{N_p} \tag{3.17}$$

and for the p^{th} trade, we obtain a vector for all problem sources:

$$\underline{DI}_p = \begin{bmatrix} DI_{1p} \\ DI_{2p} \\ \vdots \\ DI_{Kp} \end{bmatrix} \tag{3.18}$$

Generate a matrix [M] which contains the number of unique instances of each problem source for each trade, i.e.

$$[M] = \begin{bmatrix} M_{11} & M_{12} & \cdots & M_{1P} \\ M_{21} & M_{22} & \cdots & M_{2P} \\ \vdots & \vdots & & \vdots \\ M_{K1} & M_{K2} & \cdots & M_{KP} \end{bmatrix} \tag{3.19}$$

Generate a vector $\underline{N}$ which contains the number of active locations/activities for each trade, i.e.

$$[N] = \begin{bmatrix} N_1 \\ N_2 \\ \vdots \\ N_P \end{bmatrix} \tag{3.20}$$

Divide every M_{kp} by N_p for p= 1, ..., P, k=1, ...K to obtain the dispersion matrix [DI].

$$[DI] = \begin{bmatrix} DI_{11} & DI_{12} & \cdots & DI_{1P} \\ DI_{21} & DI_{22} & \cdots & DI_{2P} \\ \vdots & \vdots & & \vdots \\ DI_{K1} & DI_{K2} & \cdots & DI_{KP} \end{bmatrix} \tag{3.22}$$

Each column in Eqn. (3.22) is used as $\underline{DI}_p$ for trade analysis.

2. Compute Weights W_{kp}

For trade p, compute vector of weights $\underline{W}_p$,

where

$$\underline{W}_p = \begin{bmatrix} W_1(p) \\ W_2(p) \\ \vdots \\ W_K(p) \end{bmatrix} \tag{3.23}$$

and

$$W_{kp} = \frac{\text{Number of } \left\{ \begin{matrix} \text{occurrence} \\ \text{manhours lost} \\ \text{time lost} \end{matrix} \right\} \begin{matrix} \text{for all activities of trade } p, \\ \\ \text{problem source } k \end{matrix}}{\text{Number of } \left\{ \begin{matrix} \text{occurrence} \\ \text{manhours lost} \\ \text{time lost} \end{matrix} \right\} \begin{matrix} \text{for all activities of trade } p, \\ \\ \text{all problem sources } k \end{matrix}} \tag{3.24}$$

Then, we know that $\underline{W}_p$ is normalized, i.e.

$$\sum_{k=1}^{K} W_{kp} = 1 \tag{3.25}$$

Now, we seek to adjust these weights using the dispersion index to reflect how widely distributed each

problem source is. Our goal is to end with a renormalized set of weights.

We summarize the properties of $\underline{DI}_p$:

- It is not normalized;
- The maximum value that any entry can have is 1 (i.e. N_p unique occurrences);
- The minimum value, excluding non-occurring problem sources, is $1/N_p$.

Here, we suggest a reasonably straight forward approach for deriving a set of weights that can be used to combine the corrective action sets suggested for each problem source at the trade level.

Define

$$\hat{W}_{kp} = W_{kp} * DI_k(p) \tag{3.26}$$

and

$$W^*_{kp} = \frac{\hat{W}_{kp}}{\sum \hat{W}_{kp}} \tag{3.27}$$

Then, the vector $\underline{W}_p^*$ will be normalized.

To illustrate the foregoing, consider the following example for a single trade. Assume that for the time window under study,

K, the number of problem sources encountered = 5

N_p, the number of active locations = 10

$\underline{W}_p$, based on time lost is equal to

$$\underline{W}_p = \begin{bmatrix} W_1(p) \\ W_2(p) \\ W_3(p) \\ W_4(p) \\ W_5(p) \end{bmatrix} = \begin{bmatrix} 0.35 \\ 0.30 \\ 0.20 \\ 0.10 \\ 0.05 \end{bmatrix}$$

$\underline{DI}(p)$, the dispersion vector, is

$$\underline{DI}_p = \begin{bmatrix} .2 \\ .4 \\ .1 \\ .8 \\ .1 \end{bmatrix} \begin{array}{l} 2 \textit{ out of } 10 \textit{ locations/activities} \\ 4 \textit{ out of } 10 \textit{ locations/activities} \\ 1 \textit{ out of } 10 \textit{ locations/activities} \\ 8 \textit{ out of } 10 \textit{ locations/activiites} \\ 1 \textit{ out of } 10 \textit{ locations/activities} \end{array}$$

We know that problems at the local level have already been addressed at the activity level.

Our revised, intermediate weighted vector is:

$$\underline{\hat{W}}_p = \begin{bmatrix} 0.35 \times .2 \\ 0.30 \times .4 \\ 0.20 \times .1 \\ 0.10 \times .8 \\ 0.05 \times .1 \end{bmatrix} = \begin{bmatrix} 0.07 \\ 0.12 \\ 0.02 \\ 0.08 \\ 0.005 \end{bmatrix}$$

Thus, we have

$$\underline{W}^* = \begin{bmatrix} 0.2373 \\ 0.4068 \\ 0.0678 \\ 0.2712 \\ 0.0169 \end{bmatrix}$$

Taking into account the distribution of the various problem sources has altered considerably the weights to be used in combining the different corrective sets at the trade level.

(iv) Combining Corrective Action Sets

The corrective actions suggested for the different trade problem sources are then combined using the trade compatibility matrix and the modified weight vector to produce a reduced set of trade corrective actions. This process is identical to the one used at the activity level. A listing of the trade compatibility matrix is shown in Table 3.4.

3.3.4 Project Level Analysis

At the project level, problem sources are viewed as to how they affect all activities for all trades for a given time window. For example, if many activities, regardless of which trades are responsible for them, suffer from undermanning, then it may indicate to the project manager there is a shortage of labour in the area during this period, or that the field superintendent is not aggressive enough on trades to make them allocate enough manpower to the project. Possible corrective actions might include for the former, discussion with various trades, and the hiring of workers from outside of the local area. For the latter, possible corrective actions might embrace formal estimation of manpower requirements and then discussion with the trades.

The analysis process used for the trade level is also adopted for the project level. Hence, in this section, only selected aspects are discussed to highlight different corrective action sets, rule bases, etc..

3.3.4.1 Project problem source

Only the problem source "Undermanning" was selected for the overall project level analysis. Again, the selection of this problem source was selected based on the observations from the field study described in chapter 2. Because only one problem source has been treated, no examples of the combination of corrective actions across problem sources at the project level were explored in the thesis.

Table 3.4 Trade Level Corrective Action Coefficient

Corrective Action 1		Corrective Action 2		Coef
1.1	Assign more men to the project.	1.2	Reduce workforce size.	-1.0
		1.3	Replace crew with a more experienced one.	-1.0
		1.5	Seek additional workmen for rework.	1.0
		2.3	Acquire new subtrade.	1.0
		2.8	Open extra work order since problem originated with architect/engineer.	1.0
1.2	Reduce workforce size.	1.3	Replace crew with a more experienced one.	1.0
		1.4	Investigate alternate start of work day for crew.	1.0
		1.5	Seek additional workmen for rework.	-1.0
		2.2	Discuss with subtrade its overall performance.	1.0
1.3	Replace crew with a more experienced one.	1.5	Seek additional workmen for rework.	-1.0
		2.1	Adopt a more stringent quality control program for this trade.	1.0
		2.2	Discuss with subtrade its overall performance.	1.0
1.4	Investigate alternate start of work day for crew.	1.5	Seek additional workmen for rework.	-1.0
		2.6	Improve subtrade coordination.	1.0
		2.7	Improve architect/engineer/project manager coordination.	1.0
1.5	Seek additional workmen for rework.	2.1	Adopt a more stringent quality control program for this trade.	1.0
		2.2	Discuss with subtrade its overall performance.	1.0
		2.8	Open extra work order since problem originated with architect/engineer.	1.0
2.1	Adopt a more stringent quality control program for this trade.	2.2	Discuss with subtrade its overall performance.	1.0
		2.3	Acquire new subtrade.	1.0
2.2	Discuss with subtrade its overall performance.	2.5	Place special attention on activities for localized problem source.	1.0
		2.6	Improve subtrade coordination.	1.0
2.3	Acquire new subtrade.	2.6	Improve subtrade coordination.	1.0
2.5	Place special attention on activities for localized problem sources.	2.8	Open extra work order since problem originated with architect/engineer.	1.0
2.7	Improve architect/ engineer/ project manager coordination.	2.8	Open extra work order since problem originated with architect/engineer.	1.0

3.3.4.2 Project corrective action list

The project level corrective action list which addresses the undermanning problem source is shown in Table 3.5:

Table 3.5 Project Corrective Action List

1.0	Workforce
1.01	Hire more workers for all trades.
1.02	Dismiss the trade.
1.03	Focus labour resources on critical activities.
2.0	Management
2.01	Extend workday/utilize overtime.
2.02	Resequence the work to a better time window.
2.03	Notify owner of existing site conditions.
2.04	Special attention should be given to particular trade and/or activities.
2.05	Revise the project finish date.
2.06	Extend the durations of those activities that have problems.
2.07	Obtain estimates of activity manpower requirements and produce resource loaded schedule for all trades. Use to monitor manpower levels at site.
2.08	Discuss with various trades.

The intention here is not to construct a complete project level corrective action list but rather to show the system's applicability for analysis at the project level.

3.3.4.3 Project Level Analysis Schema

(i) Compute Project Attributes

Similar to the trade level, the entire project is now treated as a single activity, whose attributes are derived from all activities active for the time window at hand, i.e.

$$V_a = \frac{\sum_{p=1}^{P}\sum_{i=1}^{I} V_{ai}(p)}{\sum Number\ of\ activities\ for\ project} \tag{3.28}$$

and

$$\underline{V} = \begin{bmatrix} V_1 \\ V_2 \\ \vdots \\ V_A \end{bmatrix} \tag{3.29}$$

A total of 22 project attributes are computed this way, for the time window under consideration.

(ii) Determine Corrective Action for Each Problem Source

Project level expert rules

A project level expert rule base is used to link the project attributes with the corrective actions. One of the project level expert rules for the problem source "Undermanning" is shown in Figure 3.5.

```
#if current(problem, undermanning)
#then
   #if   and(project_manpower(percent_sufficient,   @suff),
            >(@suff, 0.7),
            and project(percent_critical, @pc),
            >(@pc, 0.3), <=(@pc, 0.7) )
   #then
            $ag_strength 12 01003 0.7
            #end
#end
```

Figure 3.5 Example of project level expert rules (Undermanning)

In plain English, this rule says that if the current problem is undermanning, and if for the current time window, the workforce of the whole project is sufficient 70% of the time, and if the number of critical activities for the current time frame is between 30% and 70% of the number of total current activities, then the linkage between the project attribute 12 (labour intensive) and the project corrective action 1.3 (Reassign manpower resources from buffer activities to critical activities) is recommended with a strength of 0.7.

Clearly, the challenge exists in formulating such rules so that reasonable thresholds for determining when action should be initiated can be found. Much consultation with industry personnel remains to be done to develop the rule set and threshold values.

(iii) Determine Weight for Combining Corrective Actions

1. Compute Dispersion Index

For the k^{th} problem source, we create a vector $\underline{DI}_k$ from using Equations (3.20) and (3.21) such that

$$\underline{DI}_k = \begin{bmatrix} DI_1 \\ DI_2 \\ \vdots \\ DI_K \end{bmatrix} \tag{3.30}$$

and

$$DI_k = \frac{\sum_{p=1}^{P} M_{kp}}{\sum_{p=1}^{P} N_p} \tag{3.31}$$

2. **Compute Weight W_k**

W_k is used to replace W_{kp} so that:

$$W_k = \frac{\text{Number of } \left\{ \begin{matrix} \text{occurrence} \\ \text{manhours lost} \\ \text{time lost} \end{matrix} \right\} \text{ for all activities of whole project, problem source } k}{\text{Number of } \left\{ \begin{matrix} \text{occurrence} \\ \text{manhours lost} \\ \text{time lost} \end{matrix} \right\} \text{ for all activities of whole project, all problem sources}} \qquad (3.32)$$

(iv) Combining Corrective Action Sets

Project Compatibility Matrix

The project level compatibility matrix is used with the modified weight vector to produce a reduced set of project corrective actions. The project level corrective action compatibility matrix is shown in Table 3.6.

Table 3.6 Project Level Corrective Action Coefficient

Corrective Action 1		Corrective Action 2		Coefficient
1.1	Hire more workers for all trade.	1.3	Focus labour resources on critical activities.	1.0
		2.3	Notify owner of existing site conditions.	1.0
		2.8	Discuss with various trades.	1.0
1.2	Dismiss the trade.	2.4	Special attention should be given to particular trade and/or activities.	1.0
		2.8	Discuss with various trades.	1.0
1.3	Focus labour resources on critical activities.	2.1	Extend workday/utilize overtime.	1.0
		2.2	Resequence the work to a better time window.	-1.0
		2.7	Obtain estimates of activity manpower requirements and produce resources loaded schedule for all trades. Use to monitor manpower levels at site.	1.0
2.1	Extend workday/utilize overtime.	2.2	Resequence the work to a better time window.	-1.0
2.2	Resequence the work to a better time window.	2.5	Revise the project finish date.	1.0
		2.6	Extend the durations of those activities that have problems.	1.0
		2.8	Discuss with various trades.	1.0
2.3	Notify owner of existing site conditions.	2.5	Revise the project finish date.	1.0
2.4	Special attention should be given to particular trade and/or activities.	2.6	Extend the durations of those activities that have problems.	1.0
2.5	Revise the project finish date.	2.8	Discuss with various trades.	1.0
2.6	Extend the durations of those activities that have problems.	2.7	Obtain estimates of activity manpower requirements and produce resources loaded schedule for all trades. Use to monitor manpower levels at site.	1.0
		2.8	Discuss with various trades.	1.0

3.4 EXAMPLE

A simplified example has been formulated to illustrate the process described in this chapter. Assume that the project can be described by 10 work locations and three multi-location activities, as shown in Table 3.7.

Table 3.7 Activity locations and problem incidences for example

	TRADE 1		TRADE 2
Location	Activity 1	Activity 2	Activity 3
1	3 x P1, 1 x P2	P1	
2	P1	P1	6 x P2
3	P1 , P3	P2, P3	P1 , P2
4	P1		P1 , P2
5	P1 , P2	P1	P1 , P2
6	P1		
7			
8			
9			
10			

The darkened line in Table 3.7 represents the current status of the project (i.e. work on subsequent locations has not yet commenced). Problem 1, 2 and 3 (P1, P2, P3) appear frequently during the project life cycle. With the above data, we would like to explain the analysis process at the activity, trade and project levels. Note that each location of an activity is treated as a separate activity. Thus, for the time window being examined, a total of 16 activities were commenced, in progress or completed, and 14 activities had one or more problem sources recorded against them.

1. Activity Level Analysis

To start the analysis process, consider activity one at location one.

Assume the corrective actions suggested for the individual problem sources are:

$$P1 := Z1, Z2, Z3 \text{ with strengths } \{Z_1(1)\ Z_1(2)\ Z_1(3)\} = \{0.6\ \ 0.3\ \ 0.1\}$$

$$P2 := Z1, Z4, Z5 \text{ with strengths } \{Z_2(1)\ Z_2(4)\ Z_2(5)\} = \{0.5\ \ 0.3\ \ 0.2\}$$

(i) The weights, determined by the frequency of occurrence of problem sources, are:

W_k: $W_1 = 3/4 = 0.75$

$W_2 = 1/4 = 0.25$

Therefore,

$$\underline{Z} = W_1 \begin{bmatrix} Z_1(1) \\ Z_1(2) \\ Z_1(3) \end{bmatrix} + W_2 \begin{bmatrix} Z_2(1) \\ Z_2(4) \\ Z_2(5) \end{bmatrix}$$

$$\underline{Z}\ \textit{then} = 0.75 \begin{bmatrix} 0.6 \\ 0.3 \\ 0.1 \\ 0.0 \\ 0.0 \end{bmatrix} + 0.25 \begin{bmatrix} 0.5 \\ 0.0 \\ 0.0 \\ 0.3 \\ 0.2 \end{bmatrix}$$

$$\underline{Z} = \begin{bmatrix} 0.575 \\ 0.225 \\ 0.075 \\ 0.075 \\ 0.05 \end{bmatrix} = \begin{bmatrix} Z_1(1) * W_1 + Z_2(1) * W_2 \\ Z_1(2) * W_1 \\ Z_1(3) * W_1 \\ Z_2(4) * W_2 \\ Z_2(5) * W_2 \end{bmatrix}$$

(ii) Compatibility Factors

Assume

$$\begin{bmatrix} Z_{11} & Z_{12} & Z_{13} & Z_{14} & Z_{15} \\ Z_{21} & Z_{22} & \cdots & \cdots & Z_{25} \\ \vdots & \vdots & & & \vdots \\ Z_{51} & Z_{52} & \cdots & \cdots & Z_{55} \end{bmatrix} = \begin{bmatrix} 1 & 0 & -1 & 1 & 1 \\ 0 & 1 & 1 & -1 & 0 \\ -1 & 1 & 1 & 0 & -1 \\ 1 & -1 & 0 & 1 & 1 \\ 1 & 0 & -1 & 1 & 1 \end{bmatrix}$$

$S = Z^T CF Z$

therefore,

$S = Z_1 (0.575 + 0 - 0.075 + 0.075 + 0.05) + Z_2(0 + 0.225 + 0.075 - 0.075 + 0)$

$+ Z_3(-0.575 + 0.225 + 0.075 + 0 - 0.05) + Z_4(0.575 - 0.225 + 0 + 0.075 + 0.05)$

$+ Z_5(0.575 + 0 - 0.075 + 0.075 + 0.05)$

$S = 0.625 Z_1 + 0.225 Z_2 - 0.325 Z_3 + 0.475 Z_4 + 0.625 Z_5$

Since ϕ of Z_3 is negative, we drive Z_3 to zero and assign the weight of Z_3 to the Z with largest positive ϕ_n. Since both Z_1 and Z_5 satisfy this criteria, the weight of Z_3 is distributed equally amongst them.

i.e. $Z_1 = 0.575 + 0.0375 = 0.6125$

$Z_5 = 0.05 + 0.0375 = 0.0875$

$$\begin{bmatrix} Z_1 \\ Z_2 \\ Z_3 \\ Z_4 \\ Z_5 \end{bmatrix} = \begin{bmatrix} 0.6125 \\ 0.225 \\ 0 \\ 0.075 \\ 0.0875 \end{bmatrix}$$

Therefore, S:

$$S = Z_1 (0.6125 + 0 + 0 + 0.075 + 0.0875) + Z_2(0 + 0.225 + 0 - 0.075 + 0)$$
$$+ Z_3(-0.6125 + 0.225 + 0 + 0 - 0.0875)$$
$$+ Z_4(0.6125 - 0.225 + 0 + 0.075 + 0.0875)$$
$$+ Z_5(0.6125 + 0 + 0 + 0.075 + 0.0875)$$
$$S = 0.775 Z_1 + 0.15 Z_2 - 0.475 Z_3 + 0.475 Z_4 + 0.775 Z_5$$

Since none of the $\phi_n * Z_n$ is negative for corrective actions with non-zero strengths (Z_3 has been driven to zero), stop and exit the routine.

Therefore,

$$\underline{Z}(j) = \begin{bmatrix} Z(1) \\ Z(2) \\ Z(3) \\ Z(4) \\ Z(5) \end{bmatrix} = \begin{bmatrix} 0.6125 \\ 0.225 \\ 0 \\ 0.075 \\ 0.0875 \end{bmatrix}$$

This process would then be repeated for each active location of each activity.

2. Trade Level Analysis

(i) For trade 1, compute the trade level attributes by considering all active locations of activities one and two.

Using Eqn. (3.16), the first trade attribute is calculated as:

$$V_1(1) = \frac{V_1 \text{ of Activity One} \times 6 + V_1 \text{ of Activity Two} \times 5}{11 \text{ active activities}}$$

The process is repeated for the other attributes.

(ii) Determine corrective action strengths for each trade problem source using Fayek's schema A.

Assume that the results are:

P1: Z1, Z2, Z4 with [0.5 0.4 0.1]

P2: Z3 with [1.0]

P3: Z1, Z4 with [0.5 0.5]

thus, we have:

$$Z_1 = \begin{bmatrix} 0.5 \\ 0.4 \\ 0.0 \\ 0.1 \end{bmatrix} \qquad Z_2 = \begin{bmatrix} 0.0 \\ 0.0 \\ 1.0 \\ 0.0 \end{bmatrix} \qquad Z_3 = \begin{bmatrix} 0.5 \\ 0.0 \\ 0.0 \\ 0.5 \end{bmatrix}$$

(iii) Determining Weights for Combining Corrective Actions

Assume weights are determined by frequency of occurrence.

(1). Calculate W_{kp}

$$\begin{bmatrix} W_{11} \\ W_{21} \\ W_{31} \end{bmatrix} = \begin{bmatrix} \frac{11}{16} \\ \frac{3}{16} \\ \frac{2}{16} \end{bmatrix}$$

(2). Calculate Dispersion Index

$N_1 = 11$

$M_{11} = 9$ $M_{21} = 3$ $M_{31} = 2$

$$\underline{DI}_1 = \begin{bmatrix} DI_{11} \\ DI_{21} \\ DI_{31} \end{bmatrix} = \begin{bmatrix} \frac{9}{11} \\ \frac{3}{11} \\ \frac{2}{11} \end{bmatrix}$$

(3). Get W^*_{kp}

$$W'_{kp} = W_{kp} * DI_k(p)$$

$$\hat{W}_{kp} = \begin{bmatrix} \frac{11}{16} \times \frac{9}{11} \\ \frac{3}{16} \times \frac{3}{11} \\ \frac{2}{16} \times \frac{2}{11} \end{bmatrix} = \begin{bmatrix} 0.5625 \\ 0.05114 \\ 0.02273 \end{bmatrix}$$

$$W^*_{kp} = \frac{\hat{W}_{kp}}{\sum \hat{W}_{kp}} = \begin{bmatrix} 0.8839 \\ 0.08031 \\ 0.03572 \end{bmatrix}$$

Thus, $\underline{Z}$ becomes:

$$\underline{Z} = 0.8839 \begin{bmatrix} 0.5 \\ 0.4 \\ 0.0 \\ 0.1 \end{bmatrix} + 0.08031 \begin{bmatrix} 0.0 \\ 0.0 \\ 1.0 \\ 0.0 \end{bmatrix} + 0.03572 \begin{bmatrix} 0.5 \\ 0.0 \\ 0.0 \\ 0.5 \end{bmatrix} = \begin{bmatrix} 0.4598 \\ 0.35356 \\ 0.08031 \\ 0.10625 \end{bmatrix}$$

(4). Utilize Compatibility Matrix

Assume:

$$[CF] = \begin{bmatrix} CF_{11} & CF_{12} & CF_{13} & CF_{14} \\ CF_{21} & CF_{22} & \cdots & CF_{24} \\ \vdots & \vdots & & \vdots \\ CF_{41} & CF_{42} & CF_{43} & CF_{44} \end{bmatrix} = \begin{bmatrix} 1 & 0 & -1 & 1 \\ 0 & 1 & -1 & 0 \\ -1 & -1 & 1 & 0 \\ 1 & 0 & 0 & 1 \end{bmatrix}$$

$S = Z^T CF Z$

$S = Z_1(0.4598 + 0 - 0.08031 + 0.10625) + Z_2(0 + 0.35356 - 0.08031 + 0)$

$+ Z_3(-0.4598 - 0.35356 + 0.08031 + 0)$

$+ Z_4(0.4598 + 0 + 0 + 0.10625)$

$S = 0.48574 Z_1 + 0.27325 Z_2 - 0.7331 Z_3 + 0.56425 Z_4$

Since ϕ_3 is negative, assign weight of Z_3 to Z_4 (largest ϕ)

$$New \underline{Z} = \begin{bmatrix} 0.4598 \\ 0.35356 \\ 0 \\ 0.18656 \end{bmatrix}$$

New $S = Z_1(0.4598 + 0 + 0 + 0.18656) + Z_2(0 + 0.35356 + 0 + 0)$

$+ Z_3(-0.4598 - 0.35356 + 0 + 0) + Z_4(0.4598 + 0 + 0 + 0.18656)$

$S = 0.64606 Z_1 + 0.35356 Z_2 - 0.81336 Z_3 + 0.64636 Z_4$

Since $Z_3 = 0$, all ϕ*Z's are positive. Stop and exit routine.

$$\therefore \underline{Z} = \begin{bmatrix} Z_1 \\ Z_2 \\ Z_4 \end{bmatrix} = \begin{bmatrix} 0.4598 \\ 0.35356 \\ 0.18656 \end{bmatrix}$$

for Trade 1.

3. Project Level Analysis

(i) Obtain V_a for project

(ii) Obtain corrective actions for individual problem sources at the project level.

Assume:

P1: Z1, Z2, Z4 with strengths [0.4 0.5 0.1]

P2: Z1, Z2, Z3 with strengths [0.1 0.1 0.8]

P3: Z4 with strength [1.0]

(iii) Determine Weight W_k

Assume weights are determined by frequency of occurrence

$W_1 = 14/28$

$W_2 = 12/28$

$W_3 = 2/28$

$$DI = \begin{bmatrix} DI_1 \\ DI_2 \\ DI_3 \end{bmatrix} = \begin{bmatrix} \frac{12}{16} \\ \frac{7}{16} \\ \frac{2}{16} \end{bmatrix}$$

$$\therefore W^*_k = \begin{bmatrix} 0.6563 \\ 0.3281 \\ 0.01563 \end{bmatrix}$$

$$Z = \begin{bmatrix} 0.4\times0.6563 + 0.1\times0.3281 \\ 0.5\times0.6563 + 0.1\times0.3281 \\ 0.8\times0.3281 \\ 1.0\times0.01563 + 0.1\times0.6563 \end{bmatrix} = \begin{bmatrix} 0.29533 \\ 0.36096 \\ 0.26248 \\ 0.08126 \end{bmatrix} = \begin{bmatrix} Z_1 \\ Z_2 \\ Z_3 \\ Z_4 \end{bmatrix}$$

(iv) Utilize compatibility matrix

Assume:

$$[CF] = \begin{bmatrix} CF_{11} & CF_{12} & CF_{13} & CF_{14} \\ CF_{21} & CF_{22} & \cdots & CF_{24} \\ \vdots & \vdots & & \vdots \\ CF_{41} & CF_{42} & CF_{43} & CF_{44} \end{bmatrix} = \begin{bmatrix} 1 & -1 & 0 & 0 \\ -1 & 1 & 1 & 1 \\ 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 1 \end{bmatrix}$$

$S = Z^T CF Z$

$S = Z_1 (0.29533 - 0.36096 + 0 + 0) + Z_2 (-0.29533 + 0.36096 + 0.26248 + 0.08126)$

$+ Z_3 (0 + 0.36096 + 0.26248 + 0) + Z_4 (0 + 0.36096 + 0 + 0.08126)$

$S = -0.06563\ Z_1 + 0.40937\ Z_2 + 0.62344\ Z_3 + 0.4422\ Z_4$

Since ϕ_1 is negative, assign weight of Z_1 to Z_3 (largest ϕ)

$$New\ \underline{Z} = \begin{bmatrix} 0 \\ 0.36096 \\ 0.5578 \\ 0.08126 \end{bmatrix}$$

New $S = Z_1 (0 - 0.36096 + 0 + 0) + Z_2 (0 + 0.36096 + 0.5578 + 0.08126)$

$+ Z_3 (0 + 0.36096 + 0.5578 + 0) + Z_4 (0 + 0.36096 + 0 + 0.08126)$

Since $Z_1 = 0$, all ϕ*Z's are positive. Stop and exit routine.

$$\therefore \underline{Z} = \begin{bmatrix} Z_2 \\ Z_3 \\ Z_4 \end{bmatrix} = \begin{bmatrix} 0.36096 \\ 0.5578 \\ 0.08126 \end{bmatrix}$$

for the project.

CHAPTER 4.0 TESTING AND APPLICATION

The objectives of this chapter are to describe the implementation of the concepts set forth in the previous chapter in the form of an application program and to test their applicability and validity on simplified examples. The application program was written in C by William Wong, a senior computer programmer in the construction management laboratory of the University of British Columbia, based on pseudo code prepared by the author.

4.1 PROGRAM ORGANIZATION

The schematic diagram of the system developed is shown in Figure 4.1. It can be observed that parallel structures exist for the activity, trade and project level analyses. This approach simplifies the analysis process by applying similar diagnosis schema for all levels in the analysis hierarchy.

Several building blocks were used to formulate the prototype. At the activity level, a weighting schema and compatibility matrix were added to the existing individual problem source analysis schema. For the trade and project levels, the following constituents make up the components for these two analysis levels: problem source lists, attributes, expert rule bases, corrective action lists, weighting schemes, dispersion indexes and compatibility matrices.

4.2 LIST OF PREDICATES

New predicates defined for the activity, trade and project levels of expert rules are presented here. These predicates are used to provide context information for the inference engine for evaluation of the expert rules. The system searches for the information identified in these rules and then it reports either numerical or Boolean values such as TRUE, FALSE, or UNKNOWN.

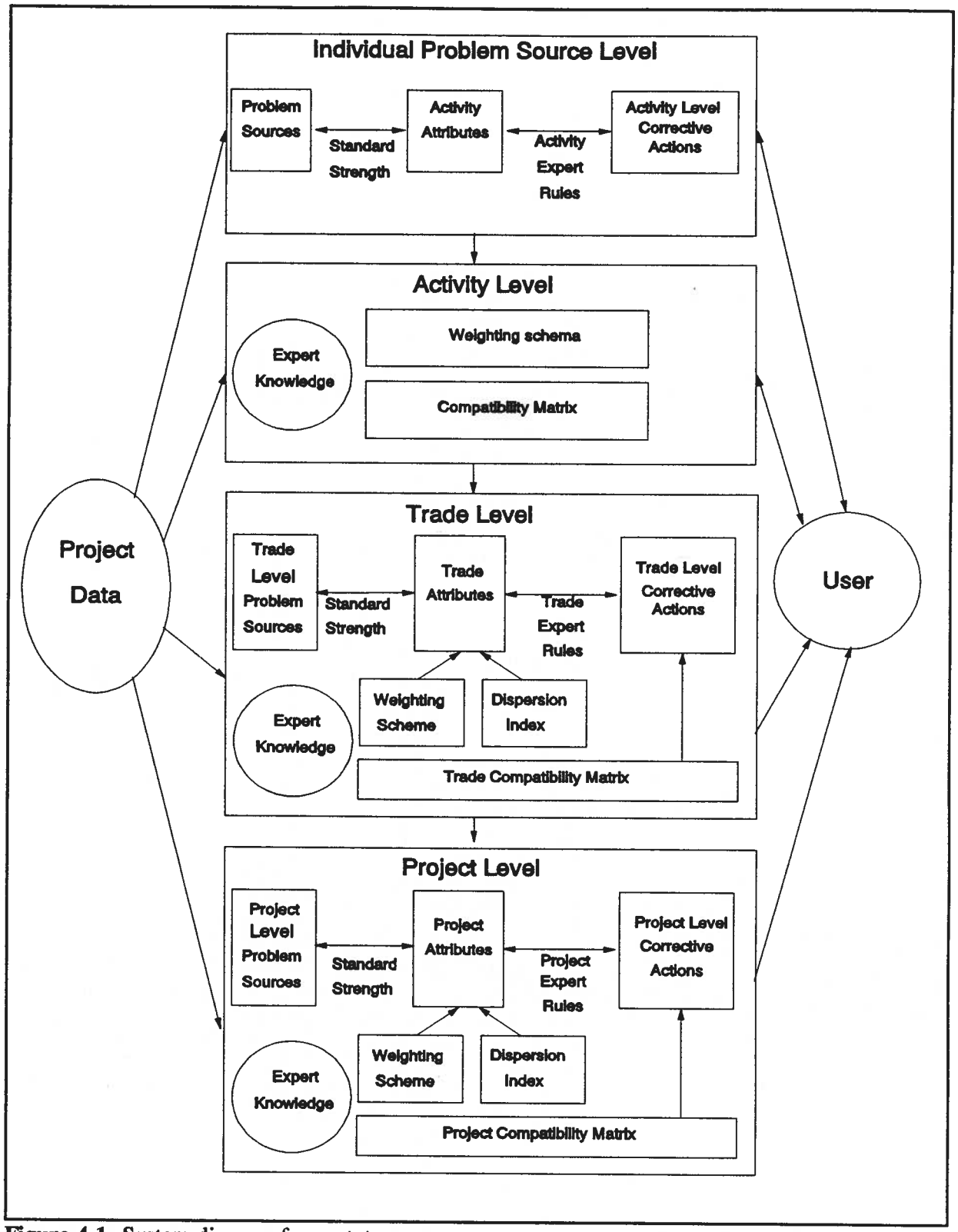

Figure 4.1 System diagram for prototype

4.2.1 SYNTAX OF THE RULES

The rules for the REPCON inference engine are expressed in the following syntax:

predicate_name(X1, X2...).

The parameters X_i in the expression are linked using the predicate predicate_name. Each predicate contains a constant number of parameters determined when the inference engine first encounters the predicate. A parameter that starts with the character @ indicates that it is a variable. A @ by itself is an unnamed variable. All other strings are constants. For example, consider the following predicate:

problem(@problem_no, resp_code, @rc)

This predicate will look up the code number for the party which was responsible for the problem @problem_no and assign it to @rc. If a value is found, this predicate will be assigned a value TRUE. Combined with predefined predicates such as AND, OR, EQ (equal), etc., different expert rules are fired. For example, if we have:

and(problem(@problem_no, resp_code, @rc), eq(@rc, g))

the system will return either a value TRUE if @rc indeed is equal to g (General Contractor), a value FALSE if @rc contains a value but it is not equal to g, or a value UNKNOWN if no value is found for the variable @rc.

4.2.2 ACTIVITY PREDICATES

New activity predicates were identified and added to the original predicates defined by Fayek (1992). They specify the information needed from the project data so that the inference engine can evaluate each expert rule to determine whether it should activate the rule. The new activity predicates, range of values, and their descriptions are listed as follows:

PREDICATES	RANGE OF VALUES	INTERPRETATION
problem(@problem_no, resp_code, @)	G, 01-99	Report the responsibility code for the party which causes the current problem.
activity(actual_duration, @)	0 - variable	Report the actual duration of the activity.
activity(freefloat, @)	0 - variable	Report the amount of free float for the current activity.
activity(respcode, @)	G, 01-99	Report which trade manages the current activity.
activity(total_manhour_lost, @)	0 - variable	Report the total number of manhours lost for this activity during the analysis time frame.
activity(total_time_lost, @)	0 - variable	Report the total amount of time lost for the current activity during the analysis time frame.
activity_problem (@problem_no, manhour_lost, @)	0 - variable	Report the number of manhours lost for the current problem source @problem_no for the current activity.

activity_problem (@problem_no, time_lost, @)	0 - variable	Report the amount of time lost for the current problem source @problem_no for the current activity.
otheractivity(freefloat)	TRUE, FALSE, UNKNOWN	Return the value TRUE if other activities of the same trade have non-zero free float in the current time window.
activity(gc, critical)	TRUE, FALSE, UNKNOWN	Return the value TRUE if the current activity belongs to the General Contractor and is critical.

4.2.3 TRADE PREDICATES

The new predicates used in the trade level expert rules of this thesis are as follows:

PREDICATE	RANGES OF VALUES	INTERPRETATION
problem_source (number-_of_occurrence, @)	1 - variable	Report the number of times this problem source appears during the analysis time frame.

trade(percent_remai- n_duration, @)	0 - 100	Report percentage of activities that are not completed for the current trade. This predicate does not limit itself to the current time frame, but rather it is computed using the whole project duration. This predicate is calculated as: (Number of unstarted activities for trade + Sum of (activity remain duration/actual duration))/(# of activities for the trade) * 100 for the total project duration.
trade(critical_act_timelost, @)	0 - variable	Report the sum of time lost due to the current problem source for critical activities of the current trade for the current analysis time window.
trade(critical_act_manhour_- lost, @)	0 - variable	Report the total manhours lost due to the current problem source for critical activities of the current trade for the analysis time window.
trade(percent_critical, @)	0 - 100	Report the percentage of activities that are critical for the current trade. It is calcu-

		lated by dividing (number of critical activities for current trade) by (total number of activities for current trade) during the analysis time frame.
number_activity(@)	0 - variable	Report the total number of activities/locations for the current trade, regardless of whether or not they are completed, started or ongoing, during the analysis time frame.
probsource(dispersion_index, @di)	0 - 1.0	Compute the dispersion index for the current problem source.
problem(@problem_no, percent_critical, @)	0 - 100	Report the percentage of the current problem source which take place on the critical activities for the trade. It is calculated by (number of occurrences for this problem source that appear on critical activities)/ (total number of occurrences of this problem source) during the analysis time frame.

trade(total_time_lost, @)	0 - variable	Report the total time lost for the current trade during the analysis time frame.
trade(total_manhour_lost, @)	0 - variable	Report the total number of man-hours lost for the current trade during the analysis time frame.
trade_problem (@problem_no, manhour_lost, @)	0 - variable	Report the number of the manhours lost for the current problem source @problem_no for the current trade for the analysis time frame.
trade_problem (@problem_no, time_lost, @)	0 - variable	Report the amount of time lost for the current problem source @problem_no for the current trade for the analysis time frame.

4.2.4 PROJECT LEVEL PREDICATES

The following list presents new predicates used at the project level of analysis.

PREDICATE	RANGES OF VALUES	DESCRIPTIONS
probsource(dispersion_index, @di)	0 - 1.0	Report the value for the dispersion index for the current project level problem

		source during the analysis time frame.
manpower(percent_sufficient, @)	0 - 100	Report the value for the percentage of days for all trades that have sufficient manpower during the analysis time frame.
project(percent_critical, @)	0 - 100	Report the percentage of activities for all locations which are critical during the analysis time frame.
project(percent_ remain_duration, @)	0 - 100	Report percentage of activities that are not completed for the project. Note that this predicate is not limited to the analysis time window but rather treats the whole duration of the project. The value is calculated by: (Total number of unstarted activities/ locations + Sum of (remaining duration of on-going activities / Actual duration for the activities)) / (Total number of activities per locations for the project)

problem(@problem_no, percent_critical, @)	0 - 100	Report the percentage of the current problem source which takes place on the critical activities for the project. It is calculated by (number of occurrences for this problem source that appear on critical activities)/ (total number of occurrences of this problem source) during the analysis time frame.
project(critical_act_time_lost, @)	0 - variable	Report the time-lost due to current problem source which occurs on critical activities of the project during the analysis time frame.
project_problem (@problem_no, manhour_lost, @)	0 - variable	Report the number of manhours lost for the current problem source @problem_no during the analysis time frame.
project_problem (@problem_no, time_lost, @)	0 - variable	Report the amount of time lost for the current problem source @problem_no during the analysis time frame.

4.3 APPLICATION INTERFACE IN REPCON

The prototype system is integrated within the educational/research version of the REPCON construction management program. The new menus which were added to the interface described by Fayek (1992) include data interpretation for trade and project levels, compatibility factor coefficients for corrective actions, and selection of the weighting criterion to be used to guide the analysis. Use of an integrated approach allows for changes, additions and deletions to be automatically accounted for. An example of the benefits of integration lies with the additions, subtractions, and modifications of the corrective action lists. Whenever corrective actions are added or subtracted, the system automatically makes the changes within the corresponding level expert rules.

Currently, the analysis schema has three levels. Figure 4.2 shows the sub-menu for "Data Interpretation" under daily site report. Under this menu, the user has two choices. He can either modify the corrective action sets and their compatibility matrix coefficients or activate the data interpretation routine for any one of the three analysis levels.

When any level (activity, trade, project) of corrective action set is selected, the screen in Figure 4.3 appears. The user can then add, delete, or revise any corrective action categories and their constituents. If the user selects "Coefficients", a new screen will appear as shown in Figure 4.4. This screen illustrates the menu for inputting compatibility coefficients for corrective actions at the activity level. Inside the menu, the user can enter the compatibility matrix by initially selecting a corrective action from Group (A). When this is completed, the system will highlight corrective actions at Group (B). Under this group, the user can enter coefficients for any corrective action to link to the corrective action initially selected in Group (A).

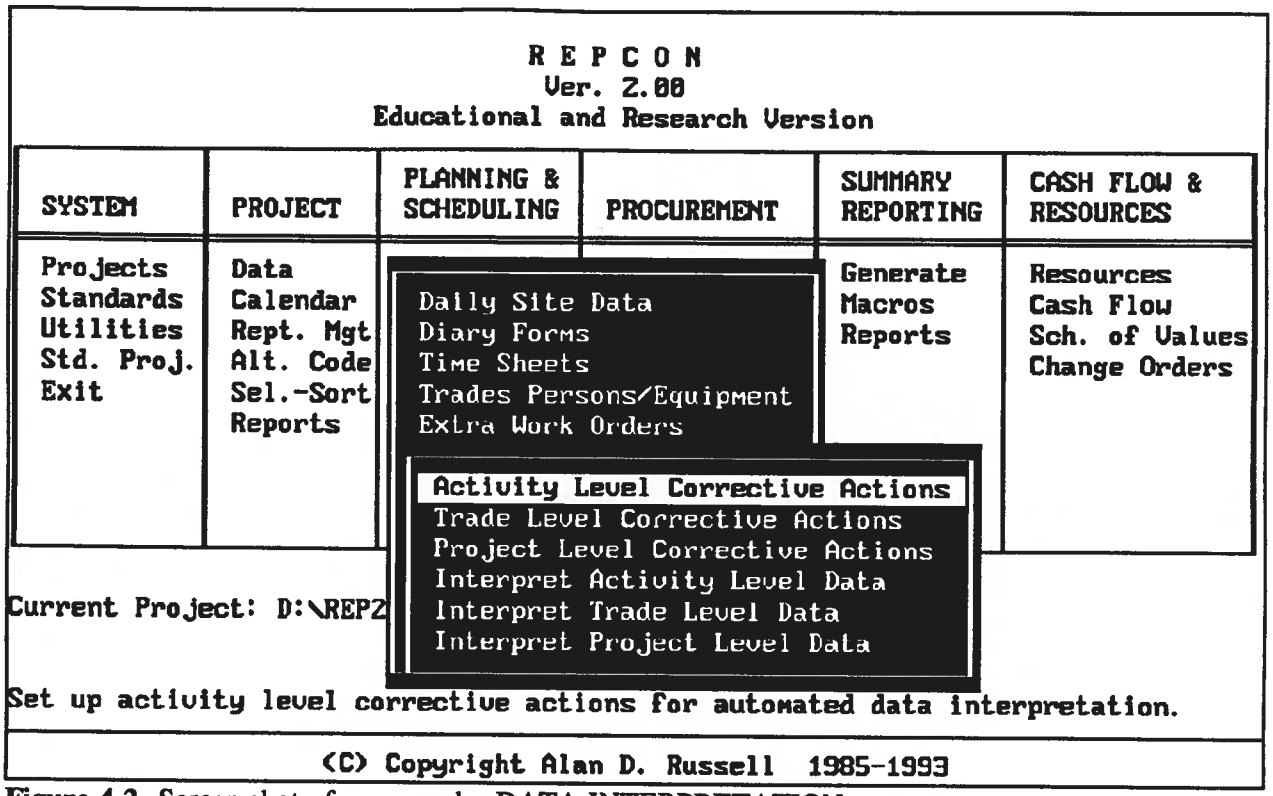

Figure 4.2 Screen shot of menu under DATA INTERPRETATION

4.4 PROCEDURE FOR AUTOMATED INTERPRETATION

The following step-by-step approach should be followed in order to create and analyze a project at any level.

(i) Create a project using REPCON. Setup activity data e.g. relationships, duration, schedule start date, attributes, milestones, etc. for the project. Check the logic of the activity and compute the schedule by selecting "Execute" under the "Planning & Scheduling" category. This process initiates a project and creates a schedule for all activities of the project.

(ii) When the project is created, go to "Problem Source" under "Daily Site". Set up the project problem sources and input their corresponding standard strengths (mapping onto the activity attribute set). This will create the base for problem sources recorded at the daily site report.

(iii) Go to "Data Interpretation" under "Daily Site" menu. When selected, another menu will be displayed. The user has two groups of choices here. Either he can modify the corrective actions

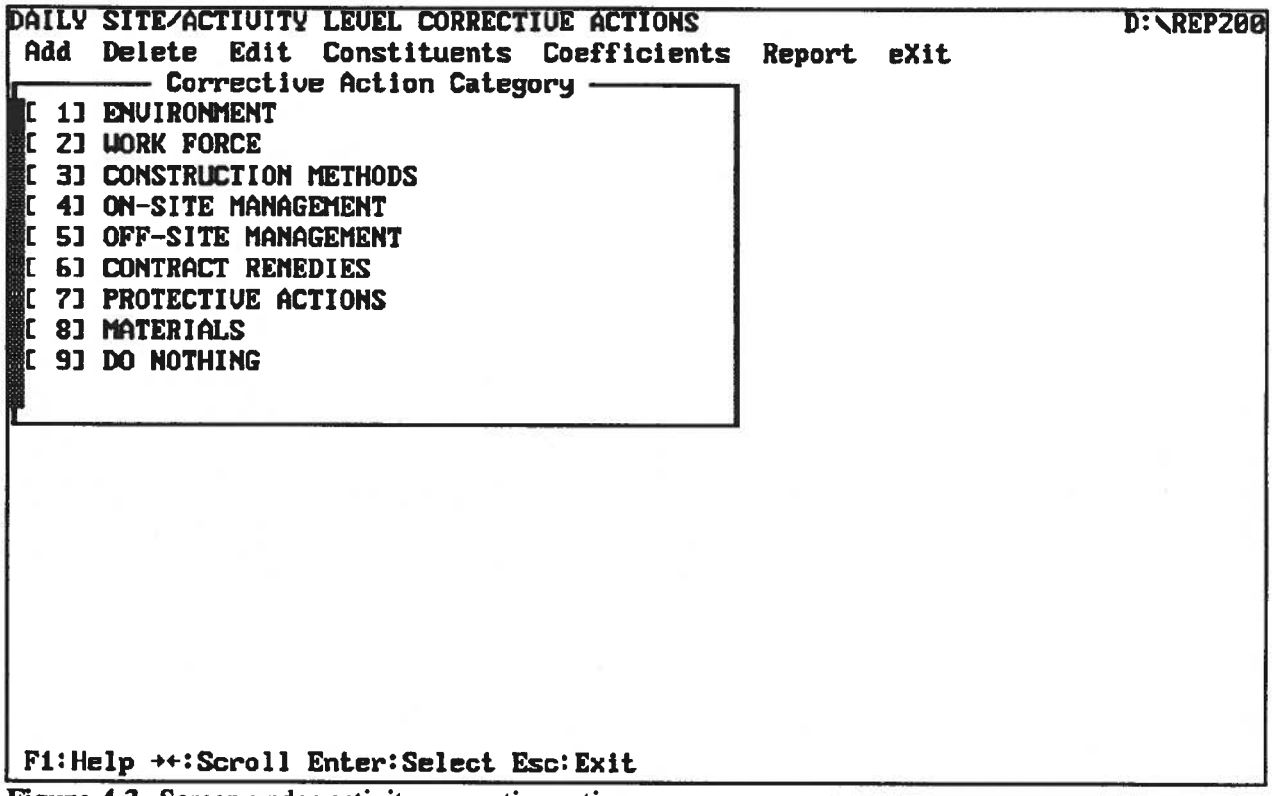

Figure 4.3 Screen under activity corrective action menu

or perform interpretation at any one level. So far, we can only modify the corrective actions because no daily site data have been entered.

(iv) When the user selects any corrective action level, a new screen will be displayed. The user can then adjust the corrective actions and their corresponding compatibility matrix. Default values have already been defined (all values except the diagonal are set to 0). However, the user can adjust the values to best reflect the project and their experience. Any value between $-1 \leq$ compatibility value ≤ 1 can be assigned. For this thesis, only values of -1, 0 or 1 have been considered.

(v) Having completed the initial project setup, go to "Daily Site Data" under "Daily Site". Setup and record the daily site activities using the daily site report. Record the progress of the activities, site conditions data, workforce data, problem sources encountered, time lost, manhours lost, etc..

(vi) When performance data for a suitable time window has been captured, go to the main menu and

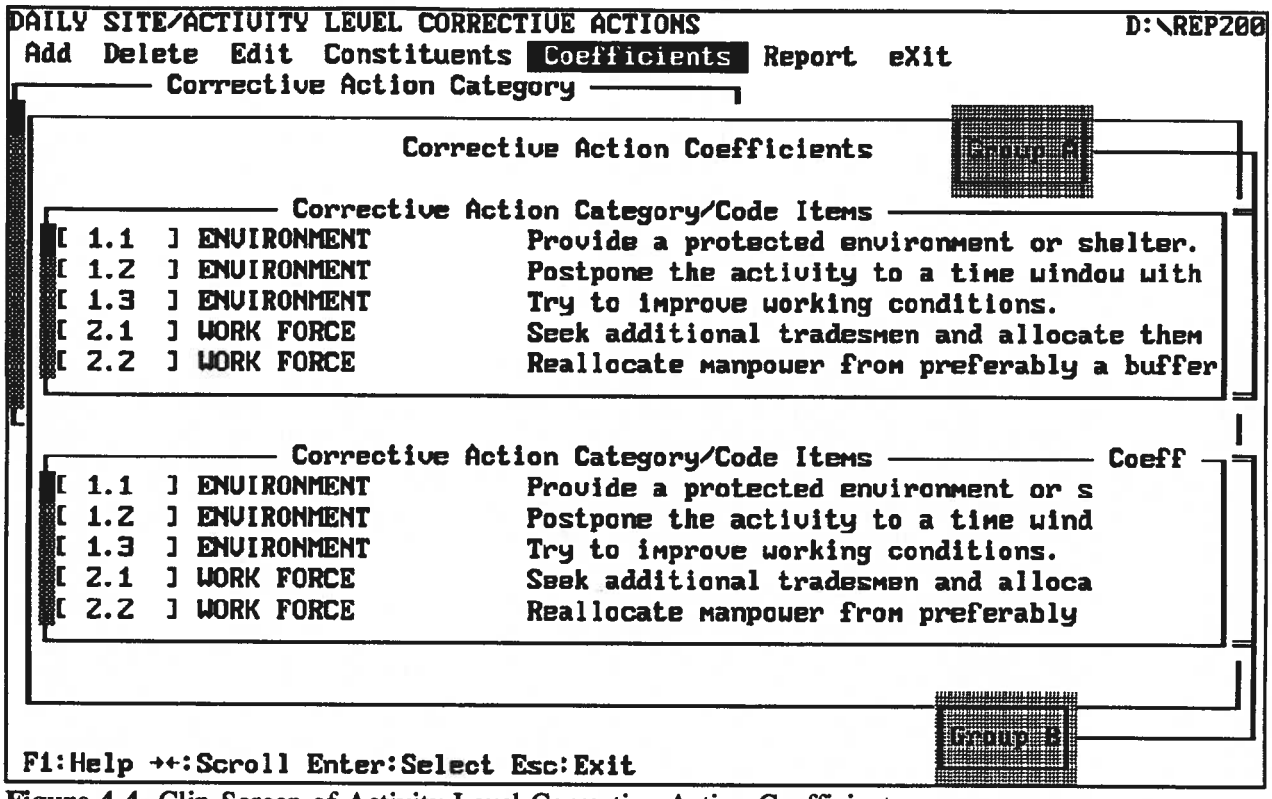

Figure 4.4 Clip Screen of Activity Level Corrective Action Coefficients

select "update project". Use "Batch Update" and select "daily site data" as input data. Specify a new progress date.

(vii) When the project is updated, re-execute the schedule to calculate a new schedule which reveals the implications of the problems encountered at the site. The data are now ready for analysis. Select "Data Interpretation" under the "Daily Site" menu in order to carry out the automated analysis.

(viii) Select the level (activity, trade, project) for interpretation. When one is selected, a new screen will be displayed as in Figure 4.5.

(ix) Enter preferences displayed on screen regarding the analysis e.g. time frame, output to, weighting criterion, etc.. The system then analyzes the daily site data using the preferences specified. The interpretation will run for several minutes to evaluate the data. An output will be generated with both the corrective actions for each individual problem source and the aggregated corrective

action set which should be considered for implementation for the level analyzed.

(x) Repeat from (viii) for other analysis levels.

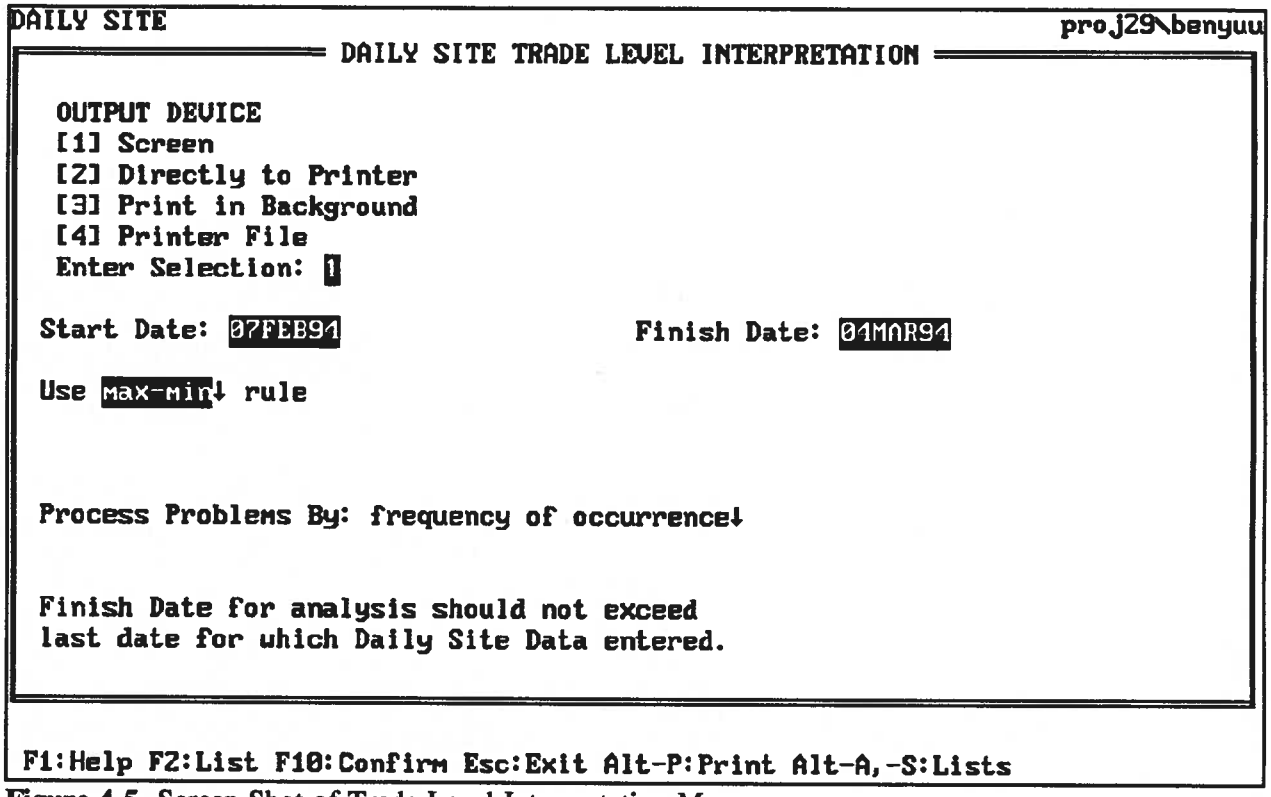

Figure 4.5 Screen Shot of Trade Level Interpretation Menu

4.5 TESTING AND VALIDATION OF THE PROTOTYPE

Two example projects were created for testing different scenarios. A highly simplified and small scale project was used with a variety of problem sources at the individual locations of an activity to test out the activity level. The responses of the system for each individual problem source were compared to the manual computations for each problem source to check the accuracy of the implementation.

For the activity, trade and project levels, a more realistic (yet still simplified) project with only a few problem sources was created. Again, the output of the computer analysis was then validated by

the manual computation of the interpretation process. Last, the usefulness of the system was tested by examining a fictional case study project which reflected some of the field experience gained (Chapter 2).

4.5.1 VALIDATION FOR ACTIVITY LEVEL ANALYSIS

4.5.1.1 PROJECT DATA

The project data used for analysis at the activity level contains three activities, ten locations and a total of two trades. Figure 4.6 shows for this example project number of work locations, activity logic, duration, attribute values, etc.. The daily site report shown in Figure 4.7 contains the information for manpower, site data, activity status, problem sources experienced, skill level, days lost, manhours lost, etc. for the two day period, 20 January, 1992 to 21 January, 1992. No attempt has been made here to be realistic in the assignment of problem sources or consequences.

UBC CONSTRUCTION MANAGEMENT LAB

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Sample test project for Benjamin's thesis (2)

Page 1 Of 2

Activity relationship report

File Used: D:\REP208\PROJ87\MTEST

Select: All Activities
Sort: Activity Code

* Critical Activity
\+ Governing predecessor of an activity or successor governed by activity

Report Date: 02DEC93
Report Time: 15:55:51
Revision Number: 0
Progress Date: 20JAN92

ACTIVITY CODE	DESCRIPTION
*810100	Activity 1

PREDECESSORS

ACT. CODE	DESCRIPTION	TYPE	PLOC	REL.	LAG	OFF/LOC
* G80100	Project Start	MT	1	FS	0	1

SUCCESSORS

ACT. CODE	DESCRIPTION	TYPE	SLOC	REL.	LAG	OFF/LOC
*+810200	Activity 2	T		FS	0	0 N

LOC_RANGE	PROD. DATA WORK	SKIP	DUR
1- 10	1	0	3

LOC	FREE FLOAT NORMAL	FREE FLOAT EXTRA	TOTAL FLOAT NORMAL	TOTAL FLOAT EXTRA	High precipitation	Low precipitation	High temperature	Low temperature	Humidity	Wind	Ground conditions	Storage on site	Site congestion	Internal access	External access	Labour intensive	Equipment intensive
* 1	0	N/A	0	N/A	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	1.00	1.00	0.00	1.00	1.00
2	0	N/A	1	N/A													
3	0	N/A	2	N/A													
4	0	N/A	3	N/A													
5	0	N/A	4	N/A													
6	0	N/A	5	N/A													
7	0	N/A	6	N/A													
8	0	N/A	7	N/A													
9	0	N/A	8	N/A													
10	9	N/A	9	N/A													

Buffer activity	Innovative methods	Design changes	High inspection	Contract provision	Controlled environment	Low tolerance	Learning curve effe	Design complexity
0.00	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00

ACTIVITY CODE	DESCRIPTION
*810200	Activity 2

PREDECESSORS

ACT. CODE	DESCRIPTION	TYPE	PLOC	REL.	LAG	OFF/LOC
*+810100	Activity 1	T		FS	0	0 N

SUCCESSORS

ACT. CODE	DESCRIPTION	TYPE	SLOC	REL.	LAG	OFF/LOC
*+820100	Activity 3	T		FS	0	0 N

LOC_RANGE	PROD. DATA WORK	SKIP	DUR
1- 10	1	0	4

LOC	FREE FLOAT NORMAL	FREE FLOAT EXTRA	TOTAL FLOAT NORMAL	TOTAL FLOAT EXTRA	High precipitation	Low precipitation	High temperature	Low temperature	Humidity	Wind	Ground conditions	Storage on site	Site congestion	Internal access	External access	Labour intensive	Equipment intensive
* 1	0	N/A	0	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00
* 2	0	N/A	0	N/A													
* 3	0	N/A	0	N/A													
* 4	0	N/A	0	N/A													
* 5	0	N/A	0	N/A													
* 6	0	N/A	0	N/A													
* 7	0	N/A	0	N/A													
* 8	0	N/A	0	N/A													
* 9	0	N/A	0	N/A													
* 10	0	N/A	0	N/A													

Buffer activity	Innovative methods	Design changes	High inspection	Contract provision	Controlled environment	Low tolerance	Learning curve effe	Design complexity
0.00	0.00	1.00	1.00	1.00	0.00	1.00	0.00	0.00

ACTIVITY CODE	DESCRIPTION
*820100	Activity 3

PREDECESSORS

ACT. CODE	DESCRIPTION	TYPE	PLOC	REL.	LAG	OFF/LOC
*+810200	Activity 2	T		FS	0	0 N

SUCCESSORS

ACT. CODE	DESCRIPTION	TYPE	SLOC	REL.	LAG	OFF/LOC
*+G80200	Project Finish	MT	10	FS	0	10

LOC_RANGE	PROD. DATA WORK	SKIP	DUR
1- 10	1	0	3

Figure 4.6 Activity relationship report for testing at activity level

LOC	FREE FLOAT NORMAL	FREE FLOAT EXTRA	TOTAL FLOAT NORMAL	TOTAL FLOAT EXTRA	High precipitation	Low precipitation	High temperature	Low temperature	Humidity	Wind	Ground conditions	Storage on site	Site congestion	Internal access	External access	Labour intensive	Equipment intensive
1	1	N/A	9	N/A	0.00	0.00	1.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	0.00	1.00	0.00
2	1	N/A	8	N/A													
3	1	N/A	7	N/A													
4	1	N/A	6	N/A													
5	1	N/A	5	N/A													
6	1	N/A	4	N/A													
7	1	N/A	3	N/A													
8	1	N/A	2	N/A													
9	1	N/A	1	N/A													
* 10	0	N/A	0	N/A													

Buffer activity	Innovative methods	Design changes	High inspection	Contract provision	Controlled environmen	Low tolerance	Learning curve effe	Design complexity
0.00	0.00	1.00	0.00	1.00	1.00	1.00	0.00	0.00

ACTIVITY CODE: *GA0100 — DESCRIPTION: Project Start

PREDECESSORS

ACT. CODE	DESCRIPTION	TYPE	PLOC	REL	LAG	OFF/LOC

SUCCESSORS

ACT. CODE	DESCRIPTION	TYPE	SLOC	REL	LAG	OFF/LOC
* B10100	Activity 1	MT	1	FS	0	1

LOC_RANGE	PROD. DATA WORK	SKIP	DUR
1- 1	1	0	N/A

LOC	FREE FLOAT NORMAL	FREE FLOAT EXTRA	TOTAL FLOAT NORMAL	TOTAL FLOAT EXTRA	High precipitation	Low precipitation	High temperature	Low temperature	Humidity	Wind	Ground conditions	Storage on site	Site congestion	Internal access	External access	Labour intensive	Equipment intensive
* 1	N/A	N/A	N/A	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Buffer activity	Innovative methods	Design changes	High inspection	Contract provision	Controlled environmen	Low tolerance	Learning curve effe	Design complexity
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

ACTIVITY CODE: *GA0200 — DESCRIPTION: Project Finish

PREDECESSORS

ACT. CODE	DESCRIPTION	TYPE	PLOC	REL	LAG	OFF/LOC
*+B20100	Activity 3	MT	10	FS	0	10

SUCCESSORS

ACT. CODE	DESCRIPTION	TYPE	SLOC	REL	LAG	OFF/LOC

LOC_RANGE	PROD. DATA WORK	SKIP	DUR
10- 10	1	0	N/A

LOC	FREE FLOAT NORMAL	FREE FLOAT EXTRA	TOTAL FLOAT NORMAL	TOTAL FLOAT EXTRA	High precipitation	Low precipitation	High temperature	Low temperature	Humidity	Wind	Ground conditions	Storage on site	Site congestion	Internal access	External access	Labour intensive	Equipment intensive
* 10	0	N/A	0	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Buffer activity	Innovative methods	Design changes	High inspection	Contract provision	Controlled environmen	Low tolerance	Learning curve effe	Design complexity
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FOR A TOTAL OF 5 ACTIVITIES

UBC CONSTRUCTION MANAGEMENT LAB

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Sample test project for Benjamin's thesis (2)

DAILY SITE REPORT - MONDAY, 20 JAN 1992

File Used: D:\REPZ00\PROJ07\NTEST
Superintendent:
Please sign: _____

Report Date: 14DEC93
Report Time: 10:20:23
Progress Date: 20JAN92
Revision Number: 0

WORK ENVIRONMENT DATA

Weather Conditions :
(a) (AM): Clear [ ] Cloudy [X] Rain [ ] Snow [ ]
(b) (PM): Clear [ ] Cloudy [X] Rain [ ] Snow [ ]
(c) Temperature: High 10C Low -3C
(d) Precipitation: 15 mm
(e) Wind: 0 kph
Site Conditions:
(f) Ground conditions: Poor [X] Fair [ ] Good [ ]
(g) Storage on site: Poor [ ] Fair [X] Good [ ]
(h) Access to site: Poor [X] Fair [ ] Good [ ]
Comments:

WORK FORCE DATA

Trade	Super (i)	Tradesmen (j)	Suf (k)	Skill H/M/L (l)	T/O H/M/L (m)	OverTime HRS (n)
01 Trade 1	1	3	N	L	L	8.00

Comments:

DELIVERIES

Item	Qty & Unit	Comment

EQUIPMENT/RENTALS

Status: (D)elivered (A)ctive (I)dle (R)eturned

Res	Item	Quantity	Status and Comment

MISCELLANEOUS NOTES

INSPECTIONS AND TESTS

VISITORS

ACCIDENTS

SITE INSTRUCTIONS

All Project Activities. Location 1 to 10.

TRADE NAME	ALT. CODE	ACTIVITY CODE	LOC	DESCRIPTION	DATES (A = ACTUAL) START	FINSH	DUR	STATUS TODAY	PROBLEM RESP	CODE	WORK PROGRESS REMARKS/ PROBLEM DESCRIPTIONS	FE TIME LOST MHRS	DAYS	ACTION CODE	REMARKS
		*C001	1	Project Start	A 20JAN	20JAN		SF							
Trade 1		*0101	1	Activity 1	A 20JAN	23JAN	4	S		(32)		3.00	3.00		
									30	(34)		6.00	4.00		
										(41)		3.00	3.00		
										(44)		3.00	2.00		
										(46)		4.00	4.00		
										(56)		3.00	3.00		
										(57)		3.00	3.00		
										(95)		3.00	4.00		

ACTIVITY STATUS CODES

F = Finished
I = Idle
O = On-going
P = Postponed
S = Started
* = Critical

PROBLEM SOURCE CODES

00 GROUP 00	10 WEATHER	20 OWNER AND CONSULTANTS	30 DESIGN/DRAWINGS	40 WORK FORCE
	11 Too much precipitation 15 Site not ready		31 Insuff./Incompl. Drawing 32 Drawing errors 34 Conflicting information	41 Insufficient manpower 44 Low skill level 46 Low motivation/morale
50 WORK	60 SUPPLIES AND EQUIPMENTS	70	80 UTILITIES/CITY	90
52 Rework (Workmanship) 56 Error in construction 57 Layout error		71 Inadequate external acc. 72 Poor ground conditions	81 Unanticipated utilities	95 Delay in award. contract

ACTION CODES

T = Telephone
L = Letter
M = Memo
B = Backcharge
E = Extra Work Order
V = Verbal Instructions

Figure 4.7 Daily site report for testing at activity level

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Sample test project for Benjamin's thesis (2)

DAILY SITE REPORT - TUESDAY, 21 JAN 1992

File Used: D:\REP200\PROJ07\MTEST
Superintendent:
Please sign: _____

Report Date: 14DEC93
Report Time: 18:20:30
Progress Date: 20JAN92
Revision Number: 0

WORK ENVIRONMENT DATA

Weather Conditions :
- (a) (AM): Clear [ ] Cloudy [X] Rain [ ] Snow [ ]
- (b) (PM): Clear [ ] Cloudy [X] Rain [ ] Snow [ ]
- (c) Temperature: High 0C Low C
- (d) Precipitation: 15 mm
- (e) Wind: 30 kph

Site Conditions:
- (f) Ground conditions: Poor [X] Fair [ ] Good [ ]
- (g) Storage on site: Poor [ ] Fair [X] Good [ ]
- (h) Access to site: Poor [X] Fair [ ] Good [ ]

Comments:

WORK FORCE DATA

Trade	Super (i)	Tradesmen (j)	Suf Y/N (k)	Skill H/M/L (l)	T/O H/M/L (m)	OverTime HRS (n)
01 Trade 1	1	4	N	L	L	0.00

Comments:

DELIVERIES

Item	Qty & Unit	Comment

EQUIPMENT/RENTALS

Status: (D)elivered (A)ctive (I)dle (R)eturned

Res	Item	Quantity	Status and Comment

MISCELLANEOUS NOTES

INSPECTIONS AND TESTS

VISITORS

ACCIDENTS

SITE INSTRUCTIONS

All Project Activities. Location 1 to 10.

TRADE NAME	ALT. CODE	ACTIVITY CODE LOC DESCRIPTION	DATES (A = ACTUAL) START FINISH DUR	STATUS TODAY	PROBLEM RESP CODE	WORK PROGRESS REMARKS/ PROBLEM DESCRIPTIONS	FE TIME LOST MHRS	DAYS	ACTION CODE REMARKS
Trade 1		*0101 1 Activity 1	A 20JAN 23JAN 4	0	01 (15) (31) (56) (95)		15.00 2.00 4.00 5.00	10.00 3.00 2.00 2.00	

ACTIVITY STATUS CODES
F = Finished
I = Idle
O = On-going
P = Postponed
S = Started
* = Critical

PROBLEM SOURCE CODES

00 GROUP 00	10 WEATHER	20 OWNER AND CONSULTANTS	30 DESIGN/DRAWINGS	40 WORK FORCE
	11 Too much precipitation 15 Site not ready		31 Insuff./Incompl. Drawing 32 Drawing errors 34 Conflicting information	41 Insufficient manpower 44 Low skill level 46 Low motivation/morale
50 WORK	60 SUPPLIES AND EQUIPMENTS	70	80 UTILITIES/CITY	90
52 Rework (Workmanship) 56 Error in construction 57 Layout error		71 Inadequate external acc. 72 Poor ground conditions	81 Unanticipated utilities	95 Delay in award. contract

ACTION CODES
T = Telephone
L = Letter
M = Memo
B = Backcharge
E = Extra Work Order
V = Verbal Instructions

4.5.1.2 COMPUTER OUTPUT FOR ANALYSIS AT ACTIVITY LEVEL

With the project data created, the daily site interpretation was first performed at the activity level. Figures 4.8, 4.9, and 4.10 show the results of using "MAX-MIN" and weighting criteria of frequency of occurrence, manhours lost and time lost, respectively. Each report contains the summary information such as trade responsible, time window under analysis, duration of the activity, remaining duration, free float and total float, activity attributes and the total amount of days and manhours lost for each activity. In addition, for each problem source the report displays both percent and number of days lost, manhours lost, and number of occurrences for each problem source, plus the corrective actions suggested and the strengths for each of them.

It is observed that for the first part of the daily site activity interpretation, i.e. the individual problem source analysis, the results are identical for all three weighting criteria used since Schema A of Fayek (1992) was used. (It is suggested for future work that Schema A incorporate the criterion specified by the user (frequency of occurrence, manhours lost, time lost), such a change has been made and only partially tested--see Appendix B for comparison results for Figures 4.8, 4.9 and 4.10.) This behaviour is expected since the weighting criteria only affects the combination of corrective actions of one activity and does not change the reasoning for the individual problem source analysis. Note that the ranking of the corrective actions for the aggregated analysis is a function of the analysis criterion specified.

4.5.1.3 MANUAL COMPUTATION AT ACTIVITY LEVEL

The manual calculations for individual problem sources at one work location of an activity verify the accuracy of the analysis process performed by the computer. The calculation is included in Appendix B. Only schema A of Fayek's routine is utilized in the calculations.

UBC CONSTRUCTION MANAGEMENT LAB

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Sample test project for Benjamin's thesis (2)

Page 1 Of 3

DAILY SITE ACTIVITY ANALYSIS REPORT

File Used: D:\REP200\PROJ07\MTEST

Report Date: 22DEC93
Report Time: 19:26:55
Revision Number: 0
Progress Date: 28JAN92

Date Window: From 28JAN92 to 21JAN92
Method used: max-min
Weighting condition: frequency of occurrence
Exclude completed activities

Activity: 010100 Activity 1 Loc: 1
Trade responsible: Trade 1
Start date: 28JAN92
Projected(Actual) finish date: 23JAN92
Total duration: 4 days
Remaining duration: 3 days, 75%
Free float: 0 days
Total float: 0 days
Total float/remaining duration: 0.00

Activity Attributes	Degree of Applicability
1 High precipitation	: 1.00
7 Ground conditions	: 1.00
9 Site congestion	: 1.00
10 Internal access	: 1.00
12 Labour intensive	: 1.00
13 Equipment intensive	: 1.00
17 High inspection	: 1.00
18 Contract provision	: 1.00

Total number of days lost: 43.00
Total number of manhours lost: 54.00

Problem Source No.	Description	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Activity Level Corrective Action No.	Description	Strength
15	Site not ready	23	10.00	20	15.00	0	1	3.5	To save time, use more equipment and less labour intensive construction method if budget and/or site conditions permit.	0.0000
								4.2	Do secondary work on the activity.	1.0000
								4.7	Investigate use of scheduled overtime.	1.0000
								5.12	Notify owner/project manager about the possibility of delay if the activity affected is a critical one.	1.0000
								6.1	Pursue a project time extension for unreasonable delay beyond contractor's control.	1.0000
								6.3	If award of the contract is delayed, ask if the owner will pay for acceleration once the contract is awarded.	1.0000
								7.3	Open a delay claim.	1.0000
31	Insuff./Incompl. Drawing	7	3.00	4	2.00	0	1		No corrective action - lack of supporting evidence	
32	Drawing errors	7	3.00	6	3.00	0	1	4.10	Note down in daily report dates of information	1.0000

Figure 4.8 Daily Site Activity Analysis Report using Frequency of Occurrence

								requested, conversations/verbal instructions, telephone calls etc..	
							5.14	Request information/clarification from architect and/or consultant(s) ASAP.	1.0000
							7.2	Issue a memo to the party concerned to request drawing completion.	1.0000
34 Conflicting information	9	4.00	11	6.00	0	1	4.18	Note down in daily report dates of information requested, conversations/verbal instructions, telephone calls etc..	1.0000
							5.9	Improve architect/engineer/consultant coordination.	1.0000
							5.15	Notify owner/project manager regarding the conflict in writing.	0.7500
							6.1	Pursue a project time extension for unreasonable delay beyond contractor's control.	0.6000
41 Insufficient manpower	7	3.00	6	3.00	0	1	2.1	Seek additional tradesmen and allocate them to activity XXYYZZ.	1.0000
44 Low skill level	5	2.00	6	3.00	0	1	2.3	Upgrade untrained personnel to trained personnel.	0.8000
							2.4	Discuss with subtrade foreman workforce performance.	1.0000
							2.9	Hire more experienced workers to lead inexperienced workers.	1.0000
							2.10	Reassign inexperienced workers to activities which do not require extensive skills.	0.5000
							2.11	Hire experienced workers and substitute for inexperienced workers.	0.7000
46 Low motivation/morale	9	4.00	7	4.00	0	1	2.1	Seek additional tradesmen and allocate them to activity XXYYZZ.	1.0000
							2.5	If low motivation is exhibited by specific crew members, lay off unproductive workers and seek new ones.	1.0000
56 Error in construction	12	5.00	13	7.00	17	2	2.1	Seek additional tradesmen and allocate them to activity XXYYZZ.	1.0000
							4.9	Reallocate tools/equipment from preferably a buffer or non-critical activity to a critical one.	0.5000
							4.10	Purchase or rent backup equipment/tools.	1.0000
							4.21	Allocate time for rework to correct error.	1.0000
							5.2	Employ a quality control program.	1.0000
							5.12	Notify owner/project manager about the possibility of delay if the activity affected is a critical one.	1.0000
							5.16	Issue speedy memo to affected parties.	1.0000
							5.17	Determine the impact of construction error on the project; if critical, seek additional trade/ workers for rework.	1.0000
							7.3	Open a delay claim.	1.0000
57 Layout error	7	3.00	6	3.00	0	1	4.15	Discuss with/notify subtrade(s) of required changes in layout.	1.0000
							5.14	Request information/clarification from architect and/or consultant(s) ASAP.	1.0000
95 Delay in award, contract	14	6.00	15	8.00	17	2	6.3	If award of the contract is delayed, ask if the owner will pay for acceleration once the contract is awarded.	1.0000

Aggregated Problems

Activity No.	Level	Corrective Action Description	Strength	Problem Number
6.3		If award of the contract is delayed, ask if the	0.1789	15 95

	owner will pay for acceleration once the contract is awarded.		
5.16	Issue speedy memo to affected parties.	0.1648	S6
2.1	Seek additional tradesmen and allocate them to activity XXYYZZ.	0.1446	41 46 S6
5.14	Request information/clarification from architect and/or consultant(s) ASAP.	0.0694	32 S7
4.18	Note down in daily report dates of information requested, conversations/verbal instructions, telephone calls etc..	0.0527	32 34
4.15	Discuss with/notify subtrade(s) of required changes in layout.	0.0417	S7
5.12	Notify owner/project manager about the possibility of delay if the activity affected is a critical one.	0.0319	15 S6
7.3	Open a delay claim.	0.0319	15 S6
7.2	Issue a memo to the party concerned to request drawing completion.	0.0278	32
6.1	Pursue a project time extension for unreasonable delay beyond contractor's control.	0.0272	15 34
5.9	Improve architect/engineer/consultant coordination.	0.0249	34
2.4	Discuss with subtrade foreman workforce performance.	0.0208	44
2.9	Hire more experienced workers to lead inexperienced workers.	0.0208	44
4.10	Purchase or rent backup equipment/tools.	0.0196	S6
4.21	Allocate time for rework to correct error.	0.0196	S6
5.2	Employ a quality control program.	0.0196	S6
5.17	Determine the impact of construction error on the project: if critical, seek additional trade/ workers for rework.	0.0196	S6
5.15	Notify owner/project manager regarding the conflict in writing.	0.0187	34
2.3	Upgrade untrained personnel to trained personnel.	0.0167	44
2.11	Hire experienced workers and substitute for inexperienced workers.	0.0146	44
4.2	Do secondary work on the activity.	0.0123	15
4.7	Investigate use of scheduled overtime.	0.0123	15
4.9	Reallocate tools/equipment from preferably a buffer or non-critical activity to a critical one.	0.0098	S6

UBC CONSTRUCTION MANAGEMENT LAB

REPCON[TM]

Sample test project for Benjamin's thesis (2)

DAILY SITE ACTIVITY ANALYSIS REPORT

File Used: D:\RCP200\PROJ07\MTEST

Report Date: 22DEC93
Report Time: 19:35:29
Revision Number: 0
Progress Date: 28JAN92

Date Window: From 28JAN92 to 21JAN92
Method used: max-min
Weighting condition: manhour_lost
Exclude completed activities

Activity: 010100 Activity 1 Loc: 1
Trade responsible: Trade 1
Start date: 28JAN92
Projected(Actual) finish date: 23JAN92
Total duration: 4 days
Remaining duration: 3 days, 75%
Free float: 0 days
Total float: 0 days
Total float/remaining duration: 0.00

Activity Attributes	Degree of Applicability
1 High precipitation	: 1.00
7 Ground conditions	: 1.00
9 Site congestion	: 1.00
10 Internal access	: 1.00
12 Labour intensive	: 1.00
13 Equipment intensive	: 1.00
17 High inspection	: 1.00
18 Contract provision	: 1.00

Total number of days lost: 43.00
Total number of manhours lost: 54.00

Problem Source No. Description	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Activity No.	Level Corrective Action Description	Strength
15 Site not ready	23	10.00	28	15.00	8	1	3.5	To save time, use more equipment and less labour intensive construction method if budget and/or site conditions permit.	0.0000
							4.2	Do secondary work on the activity.	1.0000
							4.7	Investigate use of scheduled overtime.	1.0000
							5.12	Notify owner/project manager about the possibility of delay if the activity affected is a critical one.	1.0000
							6.1	Pursue a project time extension for unreasonable delay beyond contractor's control.	1.0000
							6.3	If award of the contract is delayed, ask if the owner will pay for acceleration once the contract is awarded.	1.0000
							7.3	Open a delay claim.	1.0000
31 Insuff./Incompl. Drawing	7	3.00	4	2.00	8	1		No corrective action - lack of supporting evidence	
32 Drawing errors	7	3.00	6	3.00	8	1	4.10	Note down in daily report dates of information	1.0000

Figure 4.9 Daily Site Activity Analysis Report using Manhours Lost criterion

								requested, conversations/verbal instructions, telephone calls etc..	
							5.14	Request information/clarification from architect and/or consultant(s) ASAP.	1.0000
							7.2	Issue a memo to the party concerned to request drawing completion.	1.0000
34	Conflicting information	9	4.00	11	6.00	0	1	4.10	Note down in daily report dates of information requested, conversations/verbal instructions, telephone calls etc..	1.0000
							5.9	Improve architect/engineer/consultant coordination.	1.0000
							5.15	Notify owner/project manager regarding the conflict in writing.	0.7500
							6.1	Pursue a project time extension for unreasonable delay beyond contractor's control.	0.6000
41	Insufficient manpower	7	3.00	6	3.00	0	1	2.1	Seek additional tradesmen and allocate them to activity XXYYZZ.	1.0000
44	Low skill level	5	2.00	6	3.00	0	1	2.3	Upgrade untrained personnel to trained personnel.	0.8000
								2.4	Discuss with subtrade foreman workforce performance.	1.0000
								2.9	Hire more experienced workers to lead inexperienced workers.	1.0000
								2.10	Reassign inexperienced workers to activities which do not require extensive skills.	0.5000
								2.11	Hire experienced workers and substitute for inexperienced workers.	0.7000
46	Low motivation/morale	9	4.00	7	4.00	0	1	2.1	Seek additional tradesmen and allocate them to activity XXYYZZ.	1.0000
								2.5	If low motivation is exhibited by specific crew members, lay off unproductive workers and seek new ones.	1.0000
56	Error in construction	12	5.00	13	7.00	17	2	2.1	Seek additional tradesmen and allocate them to activity XXYYZZ.	1.0000
								4.9	Reallocate tools/equipment from preferably a buffer or non-critical activity to a critical one.	0.5000
								4.10	Purchase or rent backup equipment/tools.	1.0000
								4.21	Allocate time for rework to correct error.	1.0000
								5.2	Deploy a quality control program.	1.0000
								5.12	Notify owner/project manager about the possibility of delay if the activity affected is a critical one.	1.0000
								5.16	Issue speedy memo to affected parties.	1.0000
								5.17	Determine the impact of construction error on the project; if critical, seek additional trade/ workers for rework.	1.0000
								7.3	Open a delay claim.	1.0000
57	Layout error	7	3.00	6	3.00	0	1	4.15	Discuss with/notify subtrade(s) of required changes in layout.	1.0000
								5.14	Request information/clarification from architect and/or consultant(s) ASAP.	1.0000
95	Delay in award. contract	14	6.00	15	8.00	17	2	6.3	If award of the contract is delayed, ask if the owner will pay for acceleration once the contract is awarded.	1.0000

Aggregated Problems

Activity No.	Level Corrective Action Description	Strength	Problem Number
6.3	If award of the contract is delayed, ask if the	0.1898	15 95

	owner will pay for acceleration once the contract is awarded.		
6.1	Pursue a project time extension for unreasonable delay beyond contractor's control.	0.1744	15 34
2.1	Seek additional tradesmen and allocate them to activity XXYYZZ.	0.1078	41 46 56
5.12	Notify owner/project manager about the possibility of delay if the activity affected is a critical one.	0.0561	15 56
7.3	Open a delay claim.	0.0561	15 56
4.18	Note down in daily report dates of information requested, conversations/verbal instructions, telephone calls etc..	0.0517	32 34
5.14	Request information/clarification from architect and/or consultant(s) ASAP.	0.0463	32 57
4.2	Do secondary work on the activity.	0.0408	15
4.7	Investigate use of scheduled overtime.	0.0408	15
5.9	Improve architect/engineer/consultant coordination.	0.0332	34
4.15	Discuss with/notify subtrade(s) of required changes in layout.	0.0278	57
5.15	Notify owner/project manager regarding the conflict in writing.	0.0249	34
7.2	Issue a memo to the party concerned to request drawing completion.	0.0185	32
4.10	Purchase or rent backup equipment/tools.	0.0153	56
4.21	Allocate time for rework to correct error.	0.0153	56
5.2	Employ a quality control program.	0.0153	56
5.16	Issue speedy memo to affected parties.	0.0153	56
5.17	Determine the impact of construction error on the project: if critical, seek additional trade/ workers for rework.	0.0153	56
2.4	Discuss with subtrade foreman workforce performance.	0.0139	44
2.9	Hire more experienced workers to lead inexperienced workers.	0.0139	44
2.3	Upgrade untrained personnel to trained personnel.	0.0111	44
2.11	Hire experienced workers and substitute for inexperienced workers.	0.0097	44
4.9	Reallocate tools/equipment from preferably a buffer or non-critical activity to a critical one.	0.0076	56

DAILY SITE ACTIVITY ANALYSIS REPORT

File Used: D:\REP200\PROJ07\MTEST

Report Date: 22DEC93
Report Time: 19:48:00
Revision Number: 0
Progress Date: 28JAN92

Date Window: From 28JAN92 to 21JAN92
Method used: max-min
Weighting condition: time_lost
Exclude completed activities

Activity: 810100 Activity 1 Loc: 1
Trade responsible: Trade 1
Start date: 28JAN92
Projected(Actual) finish date: 23JAN92
Total duration: 4 days
Remaining duration: 3 days, 75%
Free float: 0 days
Total float: 0 days
Total float/remaining duration: 0.00

Activity Attributes	Degree of Applicability
1 High precipitation	: 1.00
7 Ground conditions	: 1.00
9 Site congestion	: 1.00
10 Internal access	: 1.00
12 Labour intensive	: 1.00
13 Equipment intensive	: 1.00
17 High inspection	: 1.00
18 Contract provision	: 1.00

Total number of days lost: 43.00
Total number of manhours lost: 54.00

Problem Source No.	Description	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Activity Level Corrective Action No.	Description	Strength
15	Site not ready	23	10.00	28	15.00	0	1	3.5	To save time, use more equipment and less labour intensive construction method if budget and/or site conditions permit.	0.0000
								4.2	Do secondary work on the activity.	1.0000
								4.7	Investigate use of scheduled overtime.	1.0000
								5.12	Notify owner/project manager about the possibility of delay if the activity affected is a critical one.	1.0000
								6.1	Pursue a project time extension for unreasonable delay beyond contractor's control.	1.0000
								6.3	If award of the contract is delayed, ask if the owner will pay for acceleration once the contract is awarded.	1.0000
								7.3	Open a delay claim.	1.0000
31	Insuff./Incompl. Drawing	7	3.00	4	2.00	0	1		No corrective action - lack of supporting evidence	
32	Drawing errors	7	3.00	6	3.00	0	1	4.10	Note down in daily report dates of information	1.0000

Figure 4.10 Daily Site Activity Analysis Report using Time Lost Criterion

									requested, conversations/verbal instructions, telephone calls etc..
								5.14	Request information/clarification from architect and/or consultant(s) ASAP.
								7.2	Issue a memo to the party concerned to request drawing completion.
34 Conflicting information	9	4.00	11	6.00	8	1		4.18	Note down in daily report dates of information requested, conversations/verbal instructions, telephone calls etc..
								5.9	Improve architect/engineer/consultant coordination.
								5.15	Notify owner/project manager regarding the conflict in writing.
								6.1	Pursue a project time extension for unreasonable delay beyond contractor's control.
41 Insufficient manpower	7	3.00	6	3.00	8	1		2.1	Seek additional tradesmen and allocate them to activity XXYYZZ.
44 Low skill level	5	2.00	6	3.00	8	1		2.3	Upgrade untrained personnel to trained personnel.
								2.4	Discuss with subtrade foreman workforce performance.
								2.9	Hire more experienced workers to lead inexperienced workers.
								2.10	Reassign inexperienced workers to activities which do not require extensive skills.
								2.11	Hire experienced workers and substitute for inexperienced workers.
46 Low motivation/morale	9	4.00	7	4.00	8	1		2.1	Seek additional tradesmen and allocate them to activity XXYYZZ.
								2.5	If low motivation is exhibited by specific crew members, lay off unproductive workers and seek new ones.
56 Error in construction	12	5.00	13	7.00	17	2		2.1	Seek additional tradesmen and allocate them to activity XXYYZZ.
								4.9	Reallocate tools/equipment from preferably a buffer or non-critical activity to a critical one.
								4.10	Purchase or rent backup equipment/tools.
								4.21	Allocate time for rework to correct error.
								5.2	Employ a quality control program.
								5.12	Notify owner/project manager about the possibility of delay if the activity affected is a critical one.
								5.16	Issue speedy memo to affected parties.
								5.17	Determine the impact of construction error on the project: if critical, seek additional trade/ workers for rework.
								7.3	Open a delay claim.
57 Layout error	7	3.00	6	3.00	8	1		4.15	Discuss with/notify subtrade(s) of required changes in layout.
								5.14	Request information/clarification from architect and/or consultant(s) ASAP.
95 Delay in award. contract	14	6.00	15	8.00	17	2		6.3	If award of the contract is delayed, ask if the owner will pay for acceleration once the contract is awarded.

Aggregated Problems

Activity No.	Level Corrective Action Description	Strength	Problem Number
6.1	Pursue a project time extension for unreasonable	0.2003	15 34

	delay beyond contractor's control.		
6.3	If award of the contract is delayed, ask if the owner will pay for acceleration once the contract is awarded.	0.1737	15 95
2.1	Seek additional tradesmen and allocate them to activity XXYYZZ.	0.1388	41 46 56
5.14	Request information/clarification from architect and/or consultant(s) ASAP.	0.0581	32 57
4.18	Note down in daily report dates of information requested, conversations/verbal instructions, telephone calls etc..	0.0510	32 34
5.12	Notify owner/project manager about the possibility of delay if the activity affected is a critical one.	0.0479	15 56
7.3	Open a delay claim.	0.0479	15 56
4.15	Discuss with/notify subtrade(s) of required changes in layout.	0.0349	57
4.2	Do secondary work on the activity.	0.0342	15
4.7	Investigate use of scheduled overtime.	0.0342	15
5.9	Improve architect/engineer/consultant coordination.	0.0278	34
7.2	Issue a memo to the party concerned to request drawing completion.	0.0233	32
5.15	Notify owner/project manager regarding the conflict in writing.	0.0208	34
4.10	Purchase or rent backup equipment/tools.	0.0137	56
4.21	Allocate time for rework to correct error.	0.0137	56
5.2	Employ a quality control program.	0.0137	56
5.16	Issue speedy memo to affected parties.	0.0137	56
5.17	Determine the impact of construction error on the project: if critical, seek additional trade/ workers for rework.	0.0137	56
2.4	Discuss with subtrade foreman workforce performance.	0.0116	44
2.9	Hire more experienced workers to lead inexperienced workers.	0.0116	44
2.3	Upgrade untrained personnel to trained personnel.	0.0093	44
2.11	Hire experienced workers and substitute for inexperienced workers.	0.0081	44
4.9	Reallocate tools/equipment from preferably a buffer or non-critical activity to a critical one.	0.0068	56

4.5.2 VALIDATION FOR TRADE AND PROJECT LEVEL ANALYSIS

4.5.2.1 PROJECT DATA FOR TRADE AND PROJECT LEVEL ANALYSIS

Similar to the daily site analysis at the activity level, a project was created from 20 January 1992 to 14 February, 1992. The activity report for the project is shown in Figure 4.11; the Work Environment Data Report, Work Force Data Report, and Daily Site History Report are shown in Figures 4.12, 4.13, and 4.14, respectively.

UBC CONSTRUCTION MANAGEMENT LAB

REPCON[IN]

Sample test project for Benjamin's thesis

Activity relationship report

File Used: D:\RIP200\PROJ36\TEST

Select: All Activities
Sort: Activity Code

* Critical Activity
\+ Governing predecessor of an activity or successor governed by activity

Report Date: 24NOV93
Report Time: 15:42:06
Revision Number: 0
Progress Date: 14FEB92

ACTIVITY A010100 — Activity 1

PREDECESSORS ACT. CODE	DESCRIPTION	TYPE	PLOC	REL	LAG	OFF/LOC
* C00100	Project Start	NT	1	FS	0	1

SUCCESSORS ACT. CODE	DESCRIPTION	TYPE	SLOC	REL	LAG	OFF/LOC
* 010200	Activity 2	T		FS	0	0 N

LOC_RANGE	PROD. DATA WORK	SKIP	DUR
1- 10	1	0	5

LOC	FREE FLOAT NORMAL	EXTRA	TOTAL FLOAT NORMAL	EXTRA	High precipitation	Low precipitation	High temperature	Low temperature	Humidity	Wind	Ground conditions	Storage on site	Site congestion	Internal access	External access	Labour intensive	Equipment intensive
* 1	N/A	N/A	N/A	N/A	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	1.00	1.00	0.00	0.00	1.00
2	N/A	N/A	N/A	N/A													
3	0	N/A	1	N/A													
4	0	N/A	3	N/A													
5	0	N/A	5	N/A													
6	0	N/A	7	N/A													
7	0	N/A	9	N/A													
8	0	N/A	11	N/A													
9	0	N/A	13	N/A													
10	15	N/A	15	N/A													

Buffer activity	Innovative methods	Design changes	High inspection	Contract provision	Controlled environmen	Low tolerance	Learning curve effe	Design complexity
0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00

ACTIVITY A010200 — Activity 2

PREDECESSORS ACT. CODE	DESCRIPTION	TYPE	PLOC	REL	LAG	OFF/LOC
* 010100	Activity 1	T		FS	0	0 N

SUCCESSORS ACT. CODE	DESCRIPTION	TYPE	SLOC	REL	LAG	OFF/LOC
** 020100	Activity 3	T		FS	0	0 N

LOC_RANGE	PROD. DATA WORK	SKIP	DUR
1- 10	1	0	7

LOC	FREE FLOAT NORMAL	EXTRA	TOTAL FLOAT NORMAL	EXTRA	High precipitation	Low precipitation	High temperature	Low temperature	Humidity	Wind	Ground conditions	Storage on site	Site congestion	Internal access	External access	Labour intensive	Equipment intensive
* 1	N/A	N/A	N/A	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00
* 2	0	N/A	0	N/A													
* 3	0	N/A	0	N/A													
* 4	0	N/A	0	N/A													
* 5	0	N/A	0	N/A													
* 6	0	N/A	0	N/A													
* 7	0	N/A	0	N/A													
* 8	0	N/A	0	N/A													
* 9	0	N/A	0	N/A													
* 10	0	N/A	0	N/A													

Buffer activity	Innovative methods	Design changes	High inspection	Contract provision	Controlled environmen	Low tolerance	Learning curve effe	Design complexity
0.00	0.00	1.00	1.00	1.00	0.00	1.00	0.00	0.00

ACTIVITY A020100 — Activity 3

PREDECESSORS ACT. CODE	DESCRIPTION	TYPE	PLOC	REL	LAG	OFF/LOC
** 010200	Activity 2	T		FS	0	0 N

SUCCESSORS ACT. CODE	DESCRIPTION	TYPE	SLOC	REL	LAG	OFF/LOC
** C00200	Project Finish	NT	10	FS	0	10

LOC_RANGE	PROD. DATA WORK	SKIP	DUR
1- 10	1	0	5

Figure 4.11 Activity Report for testing at trade and project levels

LOC	FREE FLOAT NORMAL	FREE FLOAT EXTRA	TOTAL FLOAT NORMAL	TOTAL FLOAT EXTRA	High precipitation	Low precipitation	High temperature	Low temperature	Humidity	Wind	Ground conditions	Storage on site	Site congestion	Internal access	External access	Labour intensive	Equipment intensive
1	0	N/A	16	N/A	0.00	0.00	1.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	0.00	1.00	0.00
2	2	N/A	16	N/A													
3	2	N/A	14	N/A													
4	2	N/A	12	N/A													
5	2	N/A	10	N/A													
6	2	N/A	8	N/A													
7	2	N/A	6	N/A													
8	2	N/A	4	N/A													
9	2	N/A	2	N/A													
* 10	0	N/A	0	N/A													

Buffer activity	Innovative methods	Design changes	High inspection	Contract provision	Controlled environmen	Low tolerance	Learning curve effe	Design complexity
0.00	0.00	1.00	0.00	1.00	1.00	1.00	0.00	0.00

ACTIVITY CODE: *G00100 — DESCRIPTION: Project Start

PREDECESSORS

ACT. CODE	DESCRIPTION	TYPE	PLOC	REL	LAG	OFF/LOC

SUCCESSORS

ACT. CODE	DESCRIPTION	TYPE	SLOC	REL	LAG	OFF/LOC
* 010100	Activity 1	MT	1	FS	0	1

LOC_RANGE	PROD. DATA WORK	PROD. DATA SKIP	PROD. DATA DUR
1- 1	1	0	N/A

LOC	FREE FLOAT NORMAL	FREE FLOAT EXTRA	TOTAL FLOAT NORMAL	TOTAL FLOAT EXTRA	High precipitation	Low precipitation	High temperature	Low temperature	Humidity	Wind	Ground conditions	Storage on site	Site congestion	Internal access	External access	Labour intensive	Equipment intensive
* 1	N/A	N/A	N/A	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Buffer activity	Innovative methods	Design changes	High inspection	Contract provision	Controlled environmen	Low tolerance	Learning curve effe	Design complexity
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

ACTIVITY CODE: *G00200 — DESCRIPTION: Project Finish

PREDECESSORS

ACT. CODE	DESCRIPTION	TYPE	PLOC	REL	LAG	OFF/LOC
**020100	Activity 3	MT	10	FS	0	10

SUCCESSORS

ACT. CODE	DESCRIPTION	TYPE	SLOC	REL	LAG	OFF/LOC

LOC_RANGE	PROD. DATA WORK	PROD. DATA SKIP	PROD. DATA DUR
10- 10	1	0	N/A

LOC	FREE FLOAT NORMAL	FREE FLOAT EXTRA	TOTAL FLOAT NORMAL	TOTAL FLOAT EXTRA	High precipitation	Low precipitation	High temperature	Low temperature	Humidity	Wind	Ground conditions	Storage on site	Site congestion	Internal access	External access	Labour intensive	Equipment intensive
* 10	0	N/A	0	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Buffer activity	Innovative methods	Design changes	High inspection	Contract provision	Controlled environmen	Low tolerance	Learning curve effe	Design complexity
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FOR A TOTAL OF 5 ACTIVITIES

UBC CONSTRUCTION MANAGEMENT LAB

REPCON™

Sample test project for Benjamin's thesis

DAILY SITE WORK ENVIRONMENT REPORT

File Used: D:\REP200\PROJ36\TEST
Report Period: 20JAN92 to 14FEB92
Weather and Site Conditions.

x Non-worked Day

Report Date: 24NOV93
Report Time: 15:39:02
Progress Date: 14FEB92
Revision Number: 0

DATE	WEATHER CONDITIONS AM (a) Clear	Cloud	Rain	Snow	PM (b) Clear	Cloud	Rain	Snow	TEMP (c) High C	Low C	(d) Precip mm	(e) Wind Speed kph	SITE CONDITIONS GROUND CONDITIONS (f) Poor	Fair	Good	STORAGE ON SITE (g) Poor	Fair	Good	ACCESS TO SITE (h) Poor	Fair	Good	COMMENTS
20JAN92		X				X			15	7	0	0		X			X			X		
21JAN92			X			X			13	5	5	20		X			X			X		
22JAN92		X					X		14	6	12	30	X				X			X		
23JAN92			X				X		13	8	15	25	X				X		X			
24JAN92		X				X			13	4	1	30	X				X		X			
27JAN92		X				X			12	2	0	20		X			X			X		
28JAN92		X				X			10	0	0	10		X			X			X		
29JAN92		X				X			15	5	3	0		X			X			X		
30JAN92		X			X				10	7	0	15		X			X			X		
31JAN92	X				X				14	5	0	15		X			X			X		
03FEB92		X			X				16	5	0	15		X			X			X		
04FEB92	X				X				10	3	0	0		X			X			X		
05FEB92	X				X				16	3	0	0		X			X			X		
06FEB92	X					X			15	4	0	0		X			X			X		
07FEB92		X				X			12	2	1	0		X			X			X		
10FEB92		X				X			15	3	0	20	X				X		X			
11FEB92		X	X			X	X		10	3	0	30	X				X		X			
12FEB92		X				X			10	2	0	10	X				X		X			
13FEB92		X			X				15	2	0	20		X			X		X			
14FEB92	X				X				17	4	0	15		X			X			X		

Figure 4.12 Work Environment Data Report for testing at trade and project levels

UBC CONSTRUCTION MANAGEMENT LAB

REPCON™

Sample test project for Benjamin's thesis

DAILY SITE WORK FORCE REPORT

File Used: D:\REP200\PROJ36\TEST
Report Period: 28JAN92 - 14FEB92
All Responsibility Codes.

Report Date: 24NOV93
Report Time: 15:39:39
Progress Date: 14FEB92
Revision Number: 0

DATE	Resp Code	Trade	(i) Super-intendent #	(j) #	(k) Sat Y/N	TRADESMEN (l) Skill H	M	L	(m) Turnover H	M	L	(n) OverTime Hours	Comments
28JAN92	G		1		Y		X				X		
	01	Trade 1	1	5	N		X				X		
21JAN92	G		1		Y		X				X		
	01	Trade 1	1	5	N		X				X		
22JAN92	G		1		Y		X				X		
	01	Trade 1	1	5	N		X				X		
23JAN92	01	Trade 1	1	6	N		X				X		
24JAN92	G		1	7	Y		X				X		
27JAN92	G		1		Y		X				X		
	01	Trade 1	1	7	Y		X				X		
28JAN92	G		1		Y		X				X		
	01	Trade 1	1	7	Y		X				X		
29JAN92	G		1		Y		X				X		
	01	Trade 1	1	7	N		X				X		
30JAN92	01	Trade 1	1	7	N		X				X		
31JAN92	G		1		Y		X				X		
	01	Trade 1	1	10	N		X				X		
03FEB92	G		1		Y		X				X		
	01	Trade 1	1	10	N		X				X		
04FEB92	G		1		Y		X				X		
	01	Trade 1	1	11	N		X				X		
05FEB92	G		1		Y		X				X		
	01	Trade 1	1	0	N		X				X		
06FEB92	G		1		Y		X				X		
	01	Trade 1	1	9	N		X				X		
07FEB92	G		1		Y		X				X		
	01	Trade 1	10		N		X				X		
	02	Trade 2	1	3	N		X				X		
10FEB92	G		1		Y		X				X		
	01	Trade 1	1	0	N			X			X		
	02	Trade 2	1	3	Y		X				X		

Figure 4.13 Work Force Data Report for testing at trade and project levels

DATE	Resp Code	Trade	(i) Super-intendent #	(j) #	(k) Suf Y/N	TRADESMEN (l) Skill H	(l) Skill M	(l) Skill L	(m) Turnover H	(m) Turnover M	(m) Turnover L	(n) OverTime Hours	Comments
11FEB92	G		1		Y		X				X		
	01	Trade 1	1	0	N		X				X		
	02	Trade 2	1	5	Y		X				X		
12FEB92	G		1		Y		X				X		
	01	Trade 1	1	5	N			X			X		
	02	Trade 2	3	8	Y	X					X		
13FEB92	G		1		Y		X				X		
	01	Trade 1	1	12	Y			X			X		
	02	Trade 2	1	6	Y		X				X		
14FEB92	G		1		Y		X				X		
	01	Trade 1	1	5	N		X				X		
	02	Trade 2	1	6	Y		X				X		

UBC CONSTRUCTION MANAGEMENT LAB

REPCON™

Sample test project for Benjamin's thesis

DAILY SITE HISTORY REPORT

File Used: D:\REP200\PROJ36\TEST
Report Period: 28JAN92 - 14FEB92
All Project Activities.

* Critical	E Extra Work Order
x Non-worked Day	L Letter
! Unscheduled	M Memo
B Backcharge	T Telephone

Report Date: 22DEC93
Report Time: 20:30:06
Progress Date: 14FEB92
Revision Number: 0

LOC	SCHEDULED/EARLY START	SCHEDULED/EARLY FINISH	SCHEDULED/EARLY DUR	ACTUAL START	ACTUAL FINISH	REM DUR	DATE & STATUS	PROBLEM RESP CODE	REMARKS & PROBLEM DESCRIPTION	ACTION	MAN HOURS LOST F_EST	MAN HOURS LOST ADJ	MAN HOURS LOST TOTAL	DAYS LOST F_EST	DAYS LOST ADJ	DAYS LOST TOTAL
Activity: 010100 Activity 1																
1	28JAN92	24JAN92	5	28JAN92	28JAN92	7	28JAN92 S	01 (32)								
								01 (34)			4.00			1.00		
							21JAN92 0	01 (41)			3.00			2.00		
							22JAN92 0	01 (41)						2.00		
							23JAN92 0	01 (41)						2.00		
							24JAN92 0							1.00		
							27JAN92 0									
							28JAN92 F									
2	31JAN92	06FEB92	5	29JAN92	04FEB92	5	29JAN92 S									
							30JAN92 0	01 (41)								
							31JAN92 0				2.00			2.00		
							03FEB92 0									
							04FEB92 F									
3	07FEB92	13FEB92	5	05FEB92	18FEB92	10	05FEB92 S									
							06FEB92 0	01 (41)								
								01 (56)			2.00			2.00		
							07FEB92 0				1.00					
							10FEB92 0	01 (41)								
							11FEB92 0				2.00			0.30		
							12FEB92 0	01 (41)								
							13FEB92 0	01 (41)						0.40		
								01 (56)			0.30			0.20		
							14FEB92 0	01 (41)			5.00			0.10		
											0.30			0.30		
										SUBTOTALS	19.60			13.30		
Activity: 010200 Activity 2																
1	31JAN92	18FEB92	7	29JAN92	06FEB92	7	29JAN92 S	01 (41)								
								(46)			3.00			1.00		
							30JAN92 0	01 (41)			10.00			0.50		
							31JAN92 0	01 (41)			2.00			0.40		
							03FEB92 0				3.00			0.30		
							04FEB92 0									
							05FEB92 0									
							06FEB92 F									
2	11FEB92	19FEB92	7	07FEB92	19FEB92	9	07FEB92 S	01 (41)								
							10FEB92 0	02 (41)						1.00		
							11FEB92 0				3.00			0.20		
							12FEB92 0	01 (41)								
								01 (56)			2.00			0.30		
							13FEB92 0	01 (41)			5.00					
								01 (56)			2.00			0.40		
							14FEB92 0	(34)			4.00					
											2.00			0.50		

Figure 4.14 Daily Site History Report for testing at trade and project levels

LOC	SCHEDULED/EARLY START	FINISH	DUR	ACTUAL START	FINISH	REM DUR	DATE & STATUS	PROBLEM RESP CODE	REMARKS & PROBLEM DESCRIPTION	ACTION	MAN HOURS LOST F_EST	ADJ	TOTAL	DAYS LOST F_EST	ADJ	TOTAL
Activity: 010200 Activity 2																
								01 (41)								
											8.40			0.30		
										SUBTOTALS	36.40			4.90		
Activity: 020100 Activity 3																
1	11FEB92	17FEB92	5	07FEB92	19FEB92	9	07FEB92 S	02 (34)								
							10FEB92 0	(34)			2.00					
							11FEB92 0	01 (41)			5.00			0.40		
							12FEB92 0				3.00			0.40		
							13FEB92 0	(34)								
							14FEB92 0	(34)			2.00			0.40		
											4.00			0.50		
										SUBTOTALS	16.00			1.70		
										TOTALS	72.00			19.90		

4.5.2.2 COMPUTER OUTPUT FOR TRADE AND PROJECT LEVEL ANALYSIS

Calculations were performed at trade and project levels using the "MAX-MIN" method. Figures 4.15, 4.16, 4.17 are analyses performed at the trade level using "MAX-MIN" method with weighting criteria of either frequency of occurrence, manhours lost, or time lost. Similarly, figures 4.18, 4.19, and 4.20 illustrate the analyses performed at the project level using "MAX-MIN" method with weighting criteria of either frequency of occurrence, manhours lost, or time lost.

4.5.2.3 MANUAL COMPUTATION AT TRADE AND PROJECT LEVEL

The manual calculations for the trade and project level analysis are presented in Appendix C and D respectively. The manual computations verified the analysis process completed by the computer. The three separate calculations for aggregating corrective actions using different weighting criteria are also shown for each calculation.

4.6 CASE STUDY EXAMPLE

After verifying the computational accuracy of the system using the previous test projects, data somewhat similar to that found in the case study described in chapter 2 was generated in order to more fully explore the prototype. Daily site data for the period of 7th February, 1994 to 4th March, 1994 were generated. Appendix E includes all the supportive information for this case study such as activity logic report, listing of activity attributes, project schedule in bar chart format, history report, project daily site data, work force report, site condition report, etc.. Table 4.1 summarizes the data interpretation runs conducted and their reports are included in Appendix F.

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Sample test project for Benjamin's thesis

DAILY SITE TRADE ANALYSIS REPORT

File Used: D:\REPCON\PROJ36\TEST

Report Date: 22DEC93
Report Time: 19:48:57
Revision Number: 0
Progress Date: 14FEB92

Date Window: From 28JAN92 to 14FEB92
Method used: max-min
Weighting condition: frequency of occurrence

Trade: 01 Trade 1
Total number of days lost: 18.20
Total number of manhours lost: 56.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
32	Drawing errors	0.200000	5	1.00	7	4.00	4	1		No corrective action - lack of supporting evidence	
34	Conflicting information	0.400000	14	2.50	9	5.00	8	2	2.1	Adopt a more stringent quality control program for this trade.	0.2000
									2.2	Discuss with subtrade its overall performance.	0.4000
									2.4	Prepare delay claim.	0.4000
									2.6	Improve subtrade coordination.	0.4000
									2.7	Improve architect/engineer/project manager coordination.	0.4000
									2.8	Open extra work order since problem originated with architect/engineer.	0.4000
41	Insufficient manpower	1.000000	77	14.10	39	22.00	68	17	1.1	Assign more men to the project.	0.4000
									1.3	Replace crew with a more experienced one.	0.4000
									2.2	Discuss with subtrade its overall performance.	0.3000
									2.3	Acquire new subtrade.	0.4000
									2.4	Prepare delay claim.	0.4000
46	Low motivation/morale	0.200000	3	0.50	18	10.00	4	1		No corrective action - lack of supporting evidence	
56	Error in construction	0.400000	1	0.10	27	15.00	16	4	1.3	Replace crew with a more experienced one.	0.4000
									1.4	Investigate alternate start of work day for crew.	0.5000
									1.5	Seek additional workmen for rework.	0.4000
									2.1	Adopt a more stringent quality control program for this trade.	0.2000
									2.2	Discuss with subtrade its overall performance.	0.4000
									2.5	Place special attention on activities for localized problem source.	0.5000

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
1.3	Replace crew with a more experienced one.	0.1938	41 56
2.4	Prepare delay claim.	0.1878	34 41
1.1	Assign more men to the project.	0.1808	41
2.3	Acquire new subtrade.	0.1808	41
2.2	Discuss with subtrade its overall performance.	0.1557	34 41 56
2.1	Adopt a more stringent quality control program for	0.0343	34 56

Figure 4.15 Analysis at Trade Level for example using Frequency of Occurrence

	this trade.		
1.4	Investigate alternate start of work day for crew.	0.0163	56
2.5	Place special attention on activities for localized problem source.	0.0163	56
1.5	Seek additional workmen for rework.	0.0130	56
2.6	Improve subtrade coordination.	0.0071	34
2.7	Improve architect/engineer/project manager coordination.	0.0071	34
2.8	Open extra work order since problem originated with architect/engineer.	0.0071	34

Trade: 02 Trade 2
Total number of days lost: 1.70
Total number of manhours lost: 16.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
34	Conflicting information	1.000000	76	1.30	81	13.00	80	4	2.1	Adopt a more stringent quality control program for this trade.	0.5000
									2.2	Discuss with subtrade its overall performance.	0.5000
									2.4	Prepare delay claim.	1.0000
									2.6	Improve subtrade coordination.	0.7000
									2.7	Improve architect/engineer/project manager coordination.	1.0000
									2.8	Open extra work order since problem originated with architect/engineer.	1.0000
41	Insufficient manpower	1.000000	24	0.40	19	3.00	20	1	1.1	Assign more men to the project.	1.0000
									1.3	Replace crew with a more experienced one.	0.5000
									2.3	Acquire new subtrade.	1.0000
									2.4	Prepare delay claim.	0.5000

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
2.4	Prepare delay claim.	0.2835	34 41
2.7	Improve architect/engineer/project manager coordination.	0.1702	34
2.8	Open extra work order since problem originated with architect/engineer.	0.1702	34
2.6	Improve subtrade coordination.	0.1191	34
2.1	Adopt a more stringent quality control program for this trade.	0.0851	34
2.2	Discuss with subtrade its overall performance.	0.0851	34
1.1	Assign more men to the project.	0.0667	41
2.3	Acquire new subtrade.	0.0667	41
1.3	Replace crew with a more experienced one.	0.0333	41

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DAILY SITE TRADE ANALYSIS REPORT

File Used: D:\REP200\PROJ36\TEST

Report Date: 22DEC93
Report Time: 19:51:59
Revision Number: 0
Progress Date: 14FEB92

Date Window: From 20JAN92 to 14FEB92
Method used: max-min
Weighting condition: manhour_lost

Trade: 01 Trade 1
Total number of days lost: 18.20
Total number of manhours lost: 56.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
32	Drawing errors	0.200000	5	1.00	7	4.00	4	1		No corrective action - lack of supporting evidence	
34	Conflicting information	0.400000	14	2.50	9	5.00	8	2	2.1	Adopt a more stringent quality control program for this trade.	0.2000
									2.2	Discuss with subtrade its overall performance.	0.4000
									2.4	Prepare delay claim.	0.4000
									2.6	Improve subtrade coordination.	0.4000
									2.7	Improve architect/engineer/project manager coordination.	0.4000
									2.8	Open extra work order since problem originated with architect/engineer.	0.4000
41	Insufficient manpower	1.000000	77	14.10	39	22.00	68	17	1.1	Assign more men to the project.	0.4000
									1.3	Replace crew with a more experienced one.	0.4000
									2.2	Discuss with subtrade its overall performance.	0.3000
									2.3	Acquire new subtrade.	0.4000
									2.4	Prepare delay claim.	0.4000
46	Low motivation/morale	0.200000	3	0.50	18	10.00	4	1		No corrective action - lack of supporting evidence	
56	Error in construction	0.400000	1	0.10	27	15.00	16	4	1.3	Replace crew with a more experienced one.	0.4000
									1.4	Investigate alternate start of work day for crew.	0.5000
									1.5	Seek additional workmen for rework.	0.4000
									2.1	Adopt a more stringent quality control program for this trade.	0.2000
									2.2	Discuss with subtrade its overall performance.	0.4000
									2.5	Place special attention on activities for localized problem source.	0.5000

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
1.3	Replace crew with a more experienced one.	0.1787	41 56
2.4	Prepare delay claim.	0.1519	34 41
2.2	Discuss with subtrade its overall performance.	0.1461	34 41 56
1.1	Assign more men to the project.	0.1412	41
2.3	Acquire new subtrade.	0.1412	41
2.1	Adopt a more stringent quality control program for	0.1135	34 56

Figure 4.16 Analysis at Trade Level Example using Manhours Lost

	this trade.		
1.4	Investigate alternate start of work day for crew.	0.0369	56
2.5	Place special attention on activities for localized problem source.	0.0369	56
1.5	Seek additional workmen for rework.	0.0295	56
2.6	Improve subtrade coordination.	0.0107	34
2.7	Improve architect/engineer/project manager coordination.	0.0107	34
2.8	Open extra work order since problem originated with architect/engineer.	0.0107	34

Trade: 02 Trade 2
Total number of days lost: 1.70
Total number of manhours lost: 16.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
34	Conflicting information	1.000000	76	1.30	81	13.00	80	4	2.1	Adopt a more stringent quality control program for this trade.	0.5000
									2.2	Discuss with subtrade its overall performance.	0.5000
									2.4	Prepare delay claim.	1.0000
									2.6	Improve subtrade coordination.	0.7000
									2.7	Improve architect/engineer/project manager coordination.	1.0000
									2.8	Open extra work order since problem originated with architect/engineer.	1.0000
41	Insufficient manpower	1.000000	24	0.40	19	3.00	20	1	1.1	Assign more men to the project.	1.0000
									1.3	Replace crew with a more experienced one.	0.5000
									2.3	Acquire new subtrade.	1.0000
									2.4	Prepare delay claim.	0.5000

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
2.4	Prepare delay claim.	0.2841	34 41
2.7	Improve architect/engineer/project manager coordination.	0.1729	34
2.8	Open extra work order since problem originated with architect/engineer.	0.1729	34
2.6	Improve subtrade coordination.	0.1210	34
2.1	Adopt a more stringent quality control program for this trade.	0.0864	34
2.2	Discuss with subtrade its overall performance.	0.0864	34
1.1	Assign more men to the project.	0.0625	41
2.3	Acquire new subtrade.	0.0625	41
1.3	Replace crew with a more experienced one.	0.0312	41

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DAILY SITE TRADE ANALYSIS REPORT

File Used: D:\REP288\PROJ36\TEST

Report Date: 22DEC93
Report Time: 19:54:28
Revision Number: 0
Progress Date: 14FEB92

Date Window: From 28JAN92 to 14FEB92
Method used: max-min
Weighting condition: time_lost

Trade: 01 Trade 1
Total number of days lost: 18.20
Total number of manhours lost: 56.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
32	Drawing errors	0.200000	5	1.00	7	4.00	4	1		No corrective action - lack of supporting evidence	
34	Conflicting information	0.400000	14	2.50	9	5.00	8	2	2.1	Adopt a more stringent quality control program for this trade.	0.2000
									2.2	Discuss with subtrade its overall performance.	0.4000
									2.4	Prepare delay claim.	0.4000
									2.6	Improve subtrade coordination.	0.4000
									2.7	Improve architect/engineer/project manager coordination.	0.4000
									2.8	Open extra work order since problem originated with architect/engineer.	0.4000
41	Insufficient manpower	1.000000	77	14.10	39	22.00	68	17	1.1	Assign more men to the project.	0.4000
									1.3	Replace crew with a more experienced one.	0.4000
									2.2	Discuss with subtrade its overall performance.	0.3000
									2.3	Acquire new subtrade.	0.4000
									2.4	Prepare delay claim.	0.4000
46	Low motivation/morale	0.200000	3	0.50	18	10.00	4	1		No corrective action - lack of supporting evidence	
56	Error in construction	0.400000	1	0.10	27	15.00	16	4	1.3	Replace crew with a more experienced one.	0.4000
									1.4	Investigate alternate start of work day for crew.	0.5000
									1.5	Seek additional workmen for rework.	0.4000
									2.1	Adopt a more stringent quality control program for this trade.	0.2000
									2.2	Discuss with subtrade its overall performance.	0.4000
									2.5	Place special attention on activities for localized problem source.	0.5000

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
2.4	Prepare delay claim.	0.2836	34 41
1.3	Replace crew with a more experienced one.	0.1927	41 56
1.1	Assign more men to the project.	0.1923	41
2.3	Acquire new subtrade.	0.1923	41
2.2	Discuss with subtrade its overall performance.	0.1568	34 41 56
2.1	Adopt a more stringent quality control program for	0.0277	34 56

Figure 4.17 Analysis at Trade Level for Example using Time Lost

	this trade.		
2.6	Improve subtrade coordination.	0.0114	34
2.7	Improve architect/engineer/project manager coordination.	0.0114	34
2.8	Open extra work order since problem originated with architect/engineer.	0.0114	34
1.4	Investigate alternate start of work day for crew.	0.0005	56
2.5	Place special attention on activities for localized problem source.	0.0005	56
1.5	Seek additional workmen for rework.	0.0004	56

Trade: 02 Trade 2
Total number of days lost: 1.70
Total number of manhours lost: 16.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
34	Conflicting information	1.000000	76	1.30	81	13.00	80	4	2.1	Adopt a more stringent quality control program for this trade.	0.5000
									2.2	Discuss with subtrade its overall performance.	0.5000
									2.4	Prepare delay claim.	1.0000
									2.6	Improve subtrade coordination.	0.7000
									2.7	Improve architect/engineer/project manager coordination.	1.0000
									2.8	Open extra work order since problem originated with architect/engineer.	1.0000
41	Insufficient manpower	1.000000	24	0.40	19	3.00	20	1	1.1	Assign more men to the project.	1.0000
									1.3	Replace crew with a more experienced one.	0.5000
									2.3	Acquire new subtrade.	1.0000
									2.4	Prepare delay claim.	0.5000

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
2.4	Prepare delay claim.	0.2819	34 41
2.7	Improve architect/engineer/project manager coordination.	0.1627	34
2.8	Open extra work order since problem originated with architect/engineer.	0.1627	34
2.6	Improve subtrade coordination.	0.1139	34
2.1	Adopt a more stringent quality control program for this trade.	0.0814	34
2.2	Discuss with subtrade its overall performance.	0.0814	34
1.1	Assign more men to the project.	0.0784	41
2.3	Acquire new subtrade.	0.0784	41
1.3	Replace crew with a more experienced one.	0.0392	41

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DAILY SITE PROJECT ANALYSIS REPORT

File Used: D:\REP200\PROJ36\TEST

Report Date: 22DEC93
Report Time: 20:00:22
Revision Number: 0
Progress Date: 14FEB92

Date Window: From 20JAN92 to 14FEB92
Method used: max-min
Weighting condition: frequency of occurrence

Total number of days lost: 19.90
Total number of manhours lost: 72.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Project Level Corrective Action No.	Description	Strength
32	Drawing errors	0.166667	5	1.00	6	4.00	3	1		No corrective action - lack of supporting evidence	
34	Conflicting information	0.500000	19	3.80	25	18.00	20	6		No corrective action - lack of supporting evidence	
41	Insufficient manpower	1.000000	73	14.50	35	25.00	60	18	1.1	Hire more workers for all trades.	0.5000
									1.3	Focus labour resources on critical activities.	0.4000
									2.3	Notify owner of existing site conditions.	0.5000
									2.5	Revise the project finish date.	0.1000
46	Low motivation/morale	0.166667	3	0.50	14	10.00	3	1		No corrective action - lack of supporting evidence	
56	Error in construction	0.333333	1	0.10	21	15.00	13	4		No corrective action - lack of supporting evidence	

Aggregated Problems

Project Level Corrective Action No.	Description	Strength	Problem Number
1.1	Hire more workers for all trades.	0.4706	41
2.3	Notify owner of existing site conditions.	0.2647	41
1.3	Focus labour resources on critical activities.	0.2118	41
2.5	Revise the project finish date.	0.0529	41

Figure 4.18 Analysis at Project Level for Example using Frequency of Occurrence

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Sample test project for Benjamin's thesis

DAILY SITE PROJECT ANALYSIS REPORT

File Used: D:\REP386\PROJ36\TEST

Report Date: 22DEC93
Report Time: 20:01:22
Revision Number: 0
Progress Date: 14FEB92

Date Window: From 29JAN92 to 14FEB92
Method used: max min
Weighting condition: manhour_lost

Total number of days lost: 19.90
Total number of manhours lost: 72.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Project Level Corrective Action No.	Description	Strength
32	Drawing errors	0.166667	5	1.00	6	4.00	3	1		No corrective action - lack of supporting evidence	
34	Conflicting information	0.500000	19	3.80	25	18.00	28	6		No corrective action - lack of supporting evidence	
41	Insufficient manpower	1.000000	73	14.50	35	25.00	60	10	1.1	Hire more workers for all trades.	0.5000
									1.3	Focus labour resources on critical activities.	0.4000
									2.3	Notify owner of existing site conditions.	0.5000
									2.5	Revise the project finish date.	0.1000
46	Low motivation/morale	0.166667	3	0.50	14	10.00	3	1		No corrective action - lack of supporting evidence	
56	Error in construction	0.333333	1	0.10	21	15.00	13	4		No corrective action - lack of supporting evidence	

Aggregated Problems

Project Level Corrective Action No.	Description	Strength	Problem Number
1.1	Hire more workers for all trades.	0.5968	41
2.3	Notify owner of existing site conditions.	0.2816	41
1.3	Focus labour resources on critical activities.	0.1613	41
2.5	Revise the project finish date.	0.0403	41

Figure 4.19 Analysis at Project Level for Example using Manhours Lost

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REPCON™

Sample test project for Benjamin's thesis

DAILY SITE PROJECT ANALYSIS REPORT

File Used: D:\REP200\PROJ36\TEST

Report Date: 22DEC93
Report Time: 20:02:36
Revision Number: 0
Progress Date: 14FEB92

Date Window: From 20JAN92 to 14FEB92
Method used: max-min
Weighting condition: time_lost

Total number of days lost: 19.90
Total number of manhours lost: 72.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Project Level Corrective Action No.	Description	Strength
32	Drawing errors	0.166667	5	1.00	6	4.00	3	1		No corrective action - lack of supporting evidence	
34	Conflicting information	0.500000	19	3.80	25	18.00	28	6		No corrective action - lack of supporting evidence	
41	Insufficient manpower	1.000000	73	14.50	35	25.00	60	18	1.1	Hire more workers for all trades.	0.5000
									1.3	Focus labour resources on critical activities.	0.4000
									2.3	Notify owner of existing site conditions.	0.5000
									2.5	Revise the project finish date.	0.1000
46	Low motivation/morale	0.166667	3	0.50	14	10.00	3	1		No corrective action - lack of supporting evidence	
56	Error in construction	0.333333	1	0.10	21	15.00	13	4		No corrective action - lack of supporting evidence	

Aggregated Problems

Project Level Corrective Action No.	Description	Strength	Problem Number
1.1	Hire more workers for all trades.	0.4206	41
2.3	Notify owner of existing site conditions.	0.2097	41
1.3	Focus labour resources on critical activities.	0.2318	41
2.5	Revise the project finish date.	0.0579	41

Figure 4.20 Analysis at Project Level for Example using Time Lost

Table 4.1 Interpretations of Case Study Example which are included in Appendix F

	Full time frame (07FEB94 - 04MAR94)			Partial time frame (07FEB94 - 18FEB94)		
	Freq.	Time Lost	MHrs Lost	Freq.	Time Lost	MHrs Lost
Activity /w completed activities	X					
Activity w/o completed activities						
Trade Level	X	X	X	X	X	X
Project Level				X	X	X

From the results of the interpretation, several conclusions were drawn:

- The project sustained the majority of its manhours lost from problem source "Too much precipitation", although it was not a wide spread problem at the site and only affected about 18% of the activities (treating each location of each activity as a separate activity) (See Figure 4.21).
- Problem source "Insufficient manpower" was one of the more frequently appearing problems (Figure 4.21). It resulted in 15.58 days lost and appeared in half of the activities at different locations (DI = 0.5); however, it was not a large contributor to manhours lost (only 6 out of 265.5 manhours lost). Overall, this problem source was a project problem that management needed to focus upon since it was not a localized problem (as compared to problem source "Insufficient / Incomplete Drawing" which had a DI of 0.107).

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BENJAMIN YUE - EXTENDED EXAMPLE PROJECT

DAILY SITE PROJECT ANALYSIS REPORT

File Used: D:\REP200\PROJ29\BDMYUU

Report Date: 22DEC93
Report Time: 21:13:00
Revision Number: 0
Progress Date: 04MAR94

Date Window: From 07FEB94 to 04MAR94
Method used: max-min
Weighting condition: frequency of occurrence

Total number of days lost: 44.23
Total number of manhours lost: 265.50

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Project Level Corrective Action No.	Description	Strength
11	Too much precipitation	0.178571	15	6.75	48	127.00	13	15		No corrective action - lack of supporting evidence	
31	Insuff./Incompl. Drawing	0.107143	5	2.25	6	17.00	5	6		No corrective action - lack of supporting evidence	
32	Drawing errors	0.071429	3	1.25	4	10.00	2	2		No corrective action - lack of supporting evidence	
34	Conflicting information	0.107143	5	2.25	10	26.00	6	7		No corrective action - lack of supporting evidence	
41	Insufficient manpower	0.500000	35	15.50	2	6.00	29	33	1.1	Hire more workers for all trades.	0.0964
									1.3	Focus labour resources on critical activities.	0.2000
									2.3	Notify owner of existing site conditions.	0.0964
									2.5	Revise the project finish date.	0.7000
44	Low skill level	0.178571	6	2.75	8	20.00	11	12		No corrective action - lack of supporting evidence	
46	Low motivation/morale	0.071429	1	0.50	5	12.00	3	3		No corrective action - lack of supporting evidence	
52	Rework (Workmanship)	0.035714	2	1.00	0	0.00	1	1		No corrective action - lack of supporting evidence	
56	Error in construction	0.178571	5	2.40	16	41.50	14	16		No corrective action - lack of supporting evidence	
57	Layout error	0.178571	13	5.75	2	6.00	8	9		No corrective action - lack of supporting evidence	
72	Poor ground conditions	0.035714	2	0.75	0	0.00	3	3		No corrective action - lack of supporting evidence	
95	Delay in award. contract	0.035714	7	3.00	0	0.00	4	5		No corrective action - lack of supporting evidence	

Aggregated Problems

Project Level Corrective Action No.	Description	Strength	Problem Number
2.3	Notify owner of existing site conditions.	0.6849	41
1.1	Hire more workers for all trades.	0.1972	41
2.5	Revise the project finish date.	0.1548	41
1.3	Focus labour resources on critical activities.	0.0448	41

Figure 4.21 Analysis at project level for Case Study using Frequency of Occurrence

- The system successfully combined the corrective actions according to the different weighting criteria. The aggregate corrective action routine worked as expected, though few corrective actions were eliminated (which confirmed our observations in chapter 3). For example, Figure 4.22 illustrates the activity analysis of "Hard Landscaping" for the analysis time frame of 07FEB94 to 04MAR94. Out of a total of 36 corrective actions, only two corrective actions (9.1 and 1.3) were eliminated during the aggregation process. If the compatibility coefficients are accurate, this result points to the need for additional input from the user dealing with relative effectiveness of different corrective actions.
- Using the same example in Figure 4.22, it is clear that some of the rules used in the thesis need review and refinement. For example, problem source "Error in Construction" suggested corrective action 7.3 (Open a delay claim) with strength of 0.5 which is not appropriate for the situation. Nevertheless, after aggregating corrective actions, this corrective action received a low priority in the suggested list of corrective actions.
- If no information is recorded for the user selected criteria, e.g. no manhours lost for a trade when the user selected manhours lost as his criterion, then the aggregation routine for the trade/project is skipped and a message "No time_lost/manhours lost for all problems of the trade" is printed out.
- Only one problem source, "undermanning", was treated at the project level; thus, the analysis for all other recorded problem sources reported "No corrective action - lack of supporting evidence".
- Only a limited number of problem sources are treated at the trade level--"Conflicting information", "Insufficient manpower", and "Construction Error". However, other untreated problem sources still take part in the corrective action aggregation routine by assigning a corrective action of "DO NOTHING - LACK OF EVIDENCE" to them.

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BENJAMIN YUE - EXTENDED EXAMPLE PROJECT

DAILY SITE ACTIVITY ANALYSIS REPORT

File Used: D:\REP200\PROJ29\BENYUU

Report Date: 23DEC93
Report Time: 10:52:24
Revision Number: 0
Progress Date: 04MAR94

Date Window: From 07FEB94 to 04MAR94
Method used: max-min
Weighting condition: frequency of occurrence
Exclude completed activities

Activity: G80300 F/R/P/C/S HARD LANDSCAPING Loc: SITE
Trade responsible: GENERAL CONTRACTOR
Start date: 09FEB94
Projected(Actual) finish date: 08MAR94
Total duration: 20 days
Remaining duration: 2 days, 10%
Free float: 67 days
Total float: 67 days
Total float/remaining duration: 33.50

Activity Attributes	Degree of Applicability
1 High precipitation	: 1.00
3 High temperature	: 0.60
4 Low temperature	: 1.00
7 Ground conditions	: 1.00
8 Storage on site	: 1.00
9 Site congestion	: 1.00
11 External access	: 1.00
12 Labour intensive	: 0.80
14 Buffer activity	: 0.50
16 Design changes	: 1.00
18 Contract provision	: 0.50
21 Learning curve effects	: 0.20
22 Design complexity	: 1.00

Total number of days lost: 9.55
Total number of manhours lost: 80.00

Problem Source No.	Description	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Activity Level Corrective Action No.	Description	Strength
11	Too much precipitation	16	1.50	19	17.00	14	4	1.1	Provide a protected environment or shelter.	0.4000
								1.2	Postpone the activity to a time window with better anticipated weather conditions.	1.0000
								3.2	Where appropriate, use extra support or shoring to alleviate poor ground conditions.	1.0000
								4.3	Increase the remaining duration on the activity.	1.0000
								6.1	Pursue a project time extension for unreasonable delay beyond contractor's control.	0.5000
								9.1	Do nothing.	0.5000
31	Insuff./Incompl. Drawing	8	0.75	8	7.00	10	3	4.1	Postpone the activity.	1.0000
								4.2	Do secondary work on the activity.	0.2000

Figure 4.22 Activity Analysis Report for Activity "Hard Landscaping" in Case Study

							4.3	Increase the remaining duration on the activity.	1.0000
							5.9	Improve architect/engineer/consultant coordination.	0.5000
							7.2	Issue a memo to the party concerned to request drawing completion.	1.0000
32 Drawing errors	3	0.25	5	4.00	3	1	2.6	When workers are idle, reroute manpower to other activities to prevent severe manpower loss.	1.0000
							4.10	Note down in daily report dates of information requested, conversations/verbal instructions, telephone calls etc..	1.0000
							5.14	Request information/clarification from architect and/or consultant(s) ASAP.	1.0000
34 Conflicting information	10	1.75	30	26.00	17	5	2.6	When workers are idle, reroute manpower to other activities to prevent severe manpower loss.	0.0000
							4.2	Do secondary work on the activity.	0.0000
							4.12	Monitor the activity closely.	1.0000
							5.9	Improve architect/engineer/consultant coordination.	1.0000
							5.10	Contact relevant parties for correction and/or information.	1.0000
41 Insufficient manpower	29	2.75	0	0.00	17	5	4.3	Increase the remaining duration on the activity.	0.0000
46 Low motivation/morale	5	0.50	9	0.00	7	2	1.3	Try to improve working conditions.	0.3000
							2.2	Reallocate manpower from preferably a buffer or non-critical activity (XXSSTT) to activity XXYYZZ.	0.5000
							2.5	If low motivation is exhibited by specific crew members, lay off unproductive workers and seek new ones.	0.7000
							2.6	When workers are idle, reroute manpower to other activities to prevent severe manpower loss.	0.5000
							4.1	Postpone the activity.	0.5000
56 Error in construction	11	1.05	23	20.00	20	8	2.2	Reallocate manpower from preferably a buffer or non-critical activity (XXSSTT) to activity XXYYZZ.	0.0000
							4.3	Increase the remaining duration on the activity.	0.5000
							4.21	Allocate time for rework to correct error.	0.0000
							5.10	Contact relevant parties for correction and/or information.	1.0000
							5.12	Notify owner/project manager about the possibility of delay if the activity affected is a critical one.	0.5000
							5.16	Issue speedy memo to affected parties.	0.5000
							5.17	Determine the impact of construction error on the project; if critical, seek additional trade/ workers for rework.	0.5000
							7.3	Open a delay claim.	0.5000
57 Layout error	10	1.00	7	6.00	3	1	4.14	Correct construction error at site immediately if possible.	0.6000
							4.15	Discuss with/notify subtrade(s) of required changes in layout.	1.0000
							5.14	Request information/clarification from architect and/or consultant(s) ASAP.	1.0000

Aggregated Problems

Activity Level Corrective Action No.	Description	Strength	Problem Number
4.3	Increase the remaining duration on the activity.	0.2508	11 31 41 56
5.10	Contact relevant parties for correction and/or information.	0.0916	34 56
2.2	Reallocate manpower from preferably a buffer or	0.0571	46 56

	non-critical activity (XXSSTT) to activity XXYYZZ.		
2.6	When workers are idle, reroute manpower to other activities to prevent severe manpower loss.	0.0553	32 34 46
5.9	Improve architect/engineer/consultant coordination.	0.0515	31 34
4.21	Allocate time for rework to correct error.	0.0433	56
4.1	Postpone the activity.	0.0418	31 46
4.12	Monitor the activity closely.	0.0375	34
4.2	Do secondary work on the activity.	0.0356	31 34
4.18	Note down in daily report dates of information requested, conversations/verbal instructions, telephone calls etc..	0.0354	32
1.2	Postpone the activity to a time window with better anticipated weather conditions.	0.0313	11
3.2	Where appropriate, use extra support or shoring to alleviate poor ground conditions.	0.0313	11
7.2	Issue a memo to the party concerned to request drawing completion.	0.0298	31
5.12	Notify owner/project manager about the possibility of delay if the activity affected is a critical one.	0.0270	56
5.16	Issue speedy memo to affected parties.	0.0270	56
5.17	Determine the impact of construction error on the project; if critical, seek additional trade/ workers for rework.	0.0270	56
7.3	Open a delay claim.	0.0270	56
5.14	Request information/clarification from architect and/or consultant(s) ASAP.	0.0248	32 57
2.5	If low motivation is exhibited by specific crew members, lay off unproductive workers and seek new ones.	0.0193	46
6.1	Pursue a project time extension for unreasonable delay beyond contractor's control.	0.0157	11
4.15	Discuss with/notify subtrade(s) of required changes in layout.	0.0133	57
1.1	Provide a protected environment or shelter.	0.0125	11
4.14	Correct construction error at site immediately if possible.	0.0088	57

- Different weighting conditions used in the analysis did effectively result in different aggregated corrective actions and corrective action rankings. An example can be observed by comparing the project analysis reports for Date Window 07FEB94 to 04MAR94 using weighting criteria of time lost and manhours lost (see Figure 4.23 and Figure 4.24). When the analysis used time lost as the weighting criteria, with a large percentage of the time loss coming from the problem source "undermanning", the corrective actions from the problem source were retained. On the other hand, when the analysis utilized manhours lost as its weighting criteria, due to the small contribution of the undermanning problem source to manhours lost (only 6 out of 265.5 manhours lost were from undermanning), the corrective actions for undermanning were effectively eliminated using the corrective action aggregation routine.
- More problem sources need to be treated at the project and trade levels. The ideal situation would be to have the same set of problem sources treated at all three analysis levels. It was observed that corrective actions from trade and project level analyses got eliminated due to this lack of treatment. A good example is displayed in the trade analysis for the drywall subcontractor (Trade 09) in Figure 4.25 accompanied by the calculations in Figure 4.26. Since many problem sources under this trade were not treated, the result led to the suggested corrective action of "DO NOTHING - LACK OF EVIDENCE". As verified from the manual calculation, the analysis procedure is correct and is a result of the small number of problem sources treated at the higher level of analysis.
- A deficiency was observed in the calculation of the dispersion index (DI) for a trade when there is only one single activity of the trade during the analytical time frame. It was observed that a DI of 1.0 would result for a problem source when the trade either worked only on a single location activity or just started at the first location of an activity for the whole project. Modifications for calculation of the dispersion index should be explored in future work.

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BENJAMIN YUE - EXTENDED EXAMPLE PROJECT

DAILY SITE PROJECT ANALYSIS REPORT

File Used: D:\REPZ00\PROJ29\BENYUU

Report Date: 22DEC93
Report Time: 21:00:27
Revision Number: 0
Progress Date: 04MAR94

Date Window: From 07FEB94 to 04MAR94
Method used: max-min
Weighting condition: time_lost

Total number of days lost: 44.23
Total number of manhours lost: 265.50

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Project Level Corrective Action No.	Description	Strength
11	Too much precipitation	0.178571	15	6.75	48	127.00	13	15		No corrective action - lack of supporting evidence	
31	Insuff./Incompl. Drawing	0.107143	5	2.25	6	17.00	5	6		No corrective action - lack of supporting evidence	
32	Drawing errors	0.071429	3	1.25	4	10.00	2	2		No corrective action - lack of supporting evidence	
34	Conflicting information	0.107143	5	2.25	10	26.00	6	7		No corrective action - lack of supporting evidence	
41	Insufficient manpower	0.500000	35	15.50	2	6.00	29	33	1.1	Hire more workers for all trades.	0.0964
									1.3	Focus labour resources on critical activities.	0.2000
									2.3	Notify owner of existing site conditions.	0.0964
									2.5	Revise the project finish date.	0.7000
44	Low skill level	0.178571	6	2.75	8	20.00	11	12		No corrective action - lack of supporting evidence	
46	Low motivation/morale	0.071429	1	0.50	5	12.00	3	3		No corrective action - lack of supporting evidence	
52	Rework (Workmanship)	0.035714	2	1.00	0	0.00	1	1		No corrective action - lack of supporting evidence	
56	Error in construction	0.178571	5	2.40	16	41.50	14	16		No corrective action - lack of supporting evidence	
57	Layout error	0.178571	13	5.75	2	6.00	0	9		No corrective action - lack of supporting evidence	
72	Poor ground conditions	0.035714	2	0.75	0	0.00	3	3		No corrective action - lack of supporting evidence	
95	Delay in award. contract	0.035714	7	3.00	0	0.00	4	5		No corrective action - lack of supporting evidence	

Aggregated Problems

Project Level Corrective Action No.	Description	Strength	Problem Number
2.3	Notify owner of existing site conditions.	0.5565	41
1.1	Hire more workers for all trades.	0.2213	41
2.5	Revise the project finish date.	0.1728	41
1.3	Focus labour resources on critical activities.	0.0494	41

Figure 4.23 Project Analysis Report for Case Study using Manhours Lost criteria from 07FEB94 to 04MAR94

UBC CONSTRUCTION MANAGEMENT LAB

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BENJAMIN YUE - EXTENDED EXAMPLE PROJECT

DAILY SITE PROJECT ANALYSIS REPORT

File Used: D:\REP288\PROJ29\BENYUU

Report Date: 22DEC93
Report Time: 21:09:47
Revision Number: 0
Progress Date: 04MAR94

Date Window: From 07FEB94 to 04MAR94
Method used: max-min
Weighting condition: manhour_lost

Total number of days lost: 44.23
Total number of manhours lost: 265.50

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Project Level Corrective Action No.	Description	Strength
11	Too much precipitation	0.178571	15	6.75	48	127.00	13	15		No corrective action - lack of supporting evidence	
31	Insuff./Incompl. Drawing	0.107143	5	2.25	6	17.00	5	6		No corrective action - lack of supporting evidence	
32	Drawing errors	0.071429	3	1.25	4	10.00	2	2		No corrective action - lack of supporting evidence	
34	Conflicting information	0.107143	5	2.25	10	26.00	6	7		No corrective action - lack of supporting evidence	
41	Insufficient manpower	0.500000	35	15.50	2	6.00	29	33	1.1	Hire more workers for all trades.	0.8964
									1.3	Focus labour resources on critical activities.	0.2000
									2.3	Notify owner of existing site conditions.	0.8964
									2.5	Revise the project finish date.	0.7000
44	Low skill level	0.178571	6	2.75	0	20.00	11	12		No corrective action - lack of supporting evidence	
46	Low motivation/morale	0.071429	1	0.50	5	12.00	3	3		No corrective action - lack of supporting evidence	
52	Rework (Workmanship)	0.035714	2	1.00	0	0.00	1	1		No corrective action - lack of supporting evidence	
56	Error in construction	0.178571	5	2.40	16	41.50	14	16		No corrective action - lack of supporting evidence	
57	Layout error	0.178571	13	5.75	2	6.00	8	9		No corrective action - lack of supporting evidence	
72	Poor ground conditions	0.035714	2	0.75	0	0.00	3	3		No corrective action - lack of supporting evidence	
95	Delay in award. contract	0.035714	7	3.00	0	0.00	4	5		No corrective action - lack of supporting evidence	

Aggregated Problems

Project Level Corrective Action No.	Description	Strength	Problem Number
	Do nothing - lack of evidence.	1.0000	11 31 32 34 44 46 56 57

Figure 4.24 Project Analysis Report for Case Study using Time Lost criteria from 07FEB94 to 04MAR94

UBC CONSTRUCTION MANAGEMENT LAB

REPCON™

BENJAMIN YUE - EXTENDED EXAMPLE PROJECT

DAILY SITE TRADE ANALYSIS REPORT

File Used: D:\REP288\PROJ29\BENYUU

Report Date: 22DEC93
Report Time: 21:15:59
Revision Number: 0
Progress Date: 04MAR94

Date Window: From 07FEB94 to 04MAR94
Method used: max-min
Weighting condition: frequency of occurrence

Trade: 09 DRYWALL INC.
Total number of days lost: 6.00
Total number of manhours lost: 6.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
32	Drawing errors	0.142857	17	1.00	100	6.00	5	1		No corrective action - lack of supporting evidence	
41	Insufficient manpower	0.428571	33	2.00	0	0.00	33	7	1.1	Assign more men to the project.	0.3000
									1.3	Replace crew with a more experienced one.	0.5000
									2.4	Prepare delay claim.	0.5000
44	Low skill level	0.285714	13	0.75	0	0.00	29	6		No corrective action - lack of supporting evidence	
52	Rework (Workmanship)	0.142857	17	1.00	0	0.00	5	1		No corrective action - lack of supporting evidence	
56	Error in construction	0.142857	8	0.50	0	0.00	10	2	1.3	Replace crew with a more experienced one.	0.5000
									1.5	Seek additional workmen for rework.	0.5000
									2.5	Place special attention on activities for localized problem source.	0.3000
57	Layout error	0.285714	13	0.75	0	0.00	19	4		No corrective action - lack of supporting evidence	

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
	Do nothing - lack of evidence.	1.0000	32 44 52 57

Figure 4.25 Trade Analysis Report for Case Study investigating effect of limited number of treated problem sources

Case study example at trade level
By Frequency of occurrence

Problem Source	DI	Freq of Occ.	W	W*DI	Normalized W*DI
32	0.142857	1	0.047619	0.006803	0.015385
41	0.428571	7	0.333333	0.142857	0.323077
44	0.285714	6	0.285714	0.081633	0.184615
52	0.142857	1	0.047619	0.006803	0.015385
56	0.142857	2	0.095238	0.013605	0.030769
57	0.285714	4	0.190476	0.190476	0.430769
Sum =		21	1	0.442177	1

Original Data

	32	41	44	52	56	57
0.0	1	0	1	1	0	1
1.1	0	0.3	0	0	0	0
1.3	0	0.5	0	0	0.5	0
1.5	0	0	0	0	0.5	0
2.4	0	0.5	0	0	0	0
2.5	0	0	0	0	0.3	0
Sum =	1	1.3	1	1	1.3	1

Normalized Strengths

	32	34	41	46	56	57
0.0	1	0	1	1	0	1
1.1	0	0.230769	0	0	0	0
1.3	0	0.384615	0	0	0.384615	0
1.5	0	0	0	0	0.384615	0
2.4	0	0.384615	0	0	0	0
2.5	0	0	0	0	0.230769	0
Sum =	1	1	1	1	1	1

Combined Adjusted Strength

	1st Data	Coeff.	2nd Data	Coeff.	3rd Data	Coeff.	4th Data	Coeff.	5th Data	Coeff.	6th Data	Coeff.
0.0	0.646154	0.292308	0.657988	0.315977	0.732544	0.465089	0.739645	0.47929	0.863905	0.727811	1	1
1.1	0.074556	-0.69586	0.074556	-0.71953	0	-0.86864	0	-0.87574	0	-1	0	-1
1.3	0.136095	-0.59645	0.136095	-0.59645	0.136095	-0.59645	0.136095	-0.60355	0.136095	-0.72781	0	-1
1.5	0.011834	-0.71953	0	-0.71953	0	-0.86864	0	-0.87574	0	-1	0	-1
2.4	0.12426	-0.52189	0.12426	-0.53373	0.12426	-0.60828	0.12426	-0.61538	0	-0.86391	0	-1
2.5	0.007101	-0.63905	0.007101	-0.65089	0.007101	-0.72544	0	-0.73965	0	-0.86391	0	-1

Figure 4.26 Calculation for Trade 09 (Drywall) to validate the effect of limited number of problem sources

4.7 SUMMARY

The results of the analysis at the activity, trade, and project levels of the case study helped to validate the analysis process of automated interpretation. Many refinements are needed for the system such as validation of the expert rules and compatibility matrix coefficients, modification in the dispersion index for single location activity, and treatment of more problem sources at the project and trade levels before the system can become a truly useful tool. Nevertheless, the results demonstrated the potential usefulness of the system for construction projects.

CHAPTER 5.0 SUMMARY AND RECOMMENDATIONS FOR FUTUREWORK

5.1 SUMMARY

With today's advancements in technology, many new decision-making tools are possible for a project manager to control a project. Two such tools, a daily site data interpretation system and graphical representation of daily site data, were described in this thesis.

The main objective of this thesis was to develop a system which could record and analyze problem sources and suggest relevant corrective actions at the activity, trade, and project levels. Using the work of Fayek (1992) as the starting point for the work, the following has been accomplished in this thesis:

(1). The number of problem sources treated by the system at the activity level has been increased from 7 to 15. The problem sources added were determined through an extensive field study.

(2). A six-month duration case study conducted on an on-going project enabled us to capture more knowledge from the construction industry. Specifically, insights into activity problem sources, corrective actions and reasoning processes linking problems with corrective actions were gained through observation of and discussion with construction experts.

(3). The ability and usefulness of graphics for viewing data site data was demonstrated. The use of graphics allows large amounts of data to be visualized quickly, assisting in the spotting of trends and correlations amongst data items.

(4) A routine was developed to combine corrective actions from individual problem sources at one work location of an activity to provide a single compatible set of corrective actions for all problem sources for that activity. The concept of compatibility coefficients was formulated for this task and a schema involving no user intervention was devised.

(5). Trade and project level analysis frameworks were developed using an analysis structure that parallels the one adopted at the activity level. Elements such as dispersion indexes, compatibility coefficients, and trade and project attributes were developed as part of the analysis schema. The open architecture of the analysis framework provides an interface that is flexible enough to be adopted for a diverse range of project types.

(6). A prototype system was implemented in REPCON and tested using progressingly more complicated examples. Valid, if somewhat simplified, corrective actions were suggested for the activities, trades and project which experienced difficulties. The accuracy of the results produced by the prototype system was verified through a series of manual calculations.

(7). Nevertheless, it was found that construction knowledge is very difficult to formulate. Much more research is needed in order to capture and document what constitutes construction expertise in the form of corrective actions, reasoning and data used to select one or more corrective actions to mitigate a problem source.

5.2 RECOMMENDATIONS FOR FUTURE WORK

Further refinements and enhancements to the prototype system are required before it can provide the basis for an operational tool for project managers. The following recommendations reflect some of the deficiencies of the current system and highlight specific parts of the system which need to be strengthened and enhanced.

Construction knowledge is difficult to formulate and document in a codified format. Much work remains to be done on the formulation and verification of expert rules. More problem sources need to be treated at the trade and project levels. Currently, only three problem sources, i.e. undermanning,

conflicting information, and construction error, are treated at the trade level and only the problem source "undermanning" is treated at the project level. This severely limits the capability of the system at the higher levels of analysis.

Another feature that needs to be addressed for the data interpretation system is the analysis of problem sources for multi-location activities as a single unit. Currently, each location is treated as an independent activity. Clearly, there is a high potential for correlation of problems and corrective actions amongst locations of a repetitive or multi-location activity. Fayek (1992) indicated that a multi-location activity should be treated with an increase in duration for all successive locations of the activity, based on the likelihood of encountering similar problems in the remaining locations. Moreover, when a detailed schedule is defined, it often happens that an activity's remaining duration at a specific location will be too short for the system to suggest proper corrective actions. A routine to combine all locations of an activity, or indeed all types of related work -- e.g. all activities related to concrete forming, into one work package is needed. This addition would lengthen the duration of a work package; and thus corrective actions suggested by the system could be suggested and implemented.

Refinements should be considered in the computation of the dispersion index which applies to problem sources assigned to activities (recall: each location of a multi-location activity is treated as a separate activity) for analysis at the trade/project level. If a trade contains only one activity location during any analytical time frame, a dispersion index of 1.0 will be given to the problem source being analyzed. This suggests that the problem source is a very widely-spread problem, which is really not the case for this situation. An enhanced DI would account for the number of activity locations active during the analysis time frame.

Moreover, the dispersion index should be modified to consider the weighting criterion selected by the user. This adjustment will produce a more meaningful result at the individual problem source analysis. The current system calculates the dispersion index only according to frequency of occurrence; thus, the individual problem source analyses using the three weighting criteria produce identical results. Consider the following example using the modified dispersion index. If a problem appears at 5 locations for a trade with 5 activity locations, and only 4 of the 5 locations have manhours lost, and if the user uses manhours lost as the weighting criterion, the current disperison index would report a value of 1.0 while the modified DI would report a value of 4/5 = 0.8.

Refinement is also needed for the compatibility matrix routine. For simplicity, this thesis limited the value of the compatibility coefficients at all analysis levels to either -1, 0, or 1. It is suggested that future researchers explore the effect of using compatibility coefficient with values within the range of -1 and 1. More work is also needed to verify whether the schema converges for all cases. To date, all evidence suggests that it does, although mathematical proof is needed to demonstrate that this is always the case.

From the results of the aggregation routine, plus a review of the compatibility matrices, it seems that there is not a great deal of conflict amongst the corrective actions. This phenomenon resulted in very few reductions of corrective actions. Future work should investigate the value of user intervention in gauging the effectiveness of various corrective actions through a feedback loop. By assigning a value to each corrective action selected, the scalar S could be optimized, potentially leading to a much reduced corrective action set. Currently, the system does not take into account which corrective actions the user implemented through a previous round of analysis. A feedback loop between the user and the system is needed to consider actions previously implemented.

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APPENDIX A STANDARD STRENGTH VALUES FOR EXAMPLES IN THESIS

APPENDIX A STANDARD STRENGTH VALUES FOR EXAMPLES IN THESIS

PROLBEM DESCRIPTION		ATTRIBUTES AND WEIGHTS	
11	Too much precipitaiton	01 High precipitation	1.00
		07 Ground Conditions	1.00
		12 Labour intensive	0.80
		13 Equipment intensive	1.00
		14 Buffer activity	1.00
		18 Contract provision	1.00
		19 Controlled environment	1.00
		20 Low tolerance	1.00
15	Site not ready	09 Site congestion	1.00
		11 External access	1.00
		12 Labour intensive	1.00
		13 Equipment intensive	1.00
		14 Buffer activity	1.00
		16 Design changes	1.00
		17 High inspection	0.50
		18 Contract provision	1.00
31	Insuff./Incompl. Drawing	12 Labour intensive	1.00
		13 Equipment intensive	1.00
		14 Buffer activity	1.00
		15 Innovative methods	1.00
		16 Design changes	1.00
32	Drawing errors	14 Buffer activity	1.00
		16 Design changes	1.00
		17 High inspection	1.00
		18 Contract provision	1.00
		19 Controlled environment	1.00
		20 Low tolerance	1.00
34	Conflicting information	09 Site congestion	1.00
		10 Internal access	1.00
		12 Labour intensive	1.00
		13 Equipment intensive	1.00
		14 Buffer activity	1.00
		16 Design changes	1.00
		18 Contract provision	1.00
		19 Controlled environment	1.00
		20 Low tolerance	1.00

41	Insufficient manpower	12 Labour intensive	1.00
		13 Equipment intensive	0.50
		14 Buffer activity	1.00
44	Low skill level	12 Labour intensive	1.00
		13 Equipment intensive	0.50
		14 Buffer activity	1.00
		15 Innovative methods	1.00
		20 Low tolerance	1.00
		22 Design complexity	1.00
46	Low motivation/morale	01 High precipitation	1.00
		03 High temperature	1.00
		05 Humidity	1.00
		12 Labour intensive	1.00
		13 Equipment intensive	1.00
		14 Buffer activity	1.00
		17 High inspection	1.00
		18 Contract provision	1.00
		19 Controlled environment	1.00
		20 Low tolerance	1.00
52	Rework (Workmanship)	12 Labour intensive	1.00
		13 Equipment intensive	0.50
		14 Buffer activity	1.00
		15 Innovative methods	1.00
		16 Design changes	0.50
		17 High inspection	1.00
		20 Low tolerance	1.00
56	Error in construction	09 Site congestion	1.00
		12 Labour intensive	1.00
		13 Equipment intensive	1.00
		14 Buffer activity	1.00
		15 Innovative methods	1.00
		16 Design changes	1.00
		17 High inspection	1.00
		18 Contract provision	1.00
		20 Low tolerance	1.00
		22 Design complexity	1.00
57	Layout error	09 Site congestion	1.00
		10 Internal access	1.00
		12 Labour intensive	1.00
		16 Design changes	1.00
		17 High inspection	1.00
		18 Contract provision	1.00
		22 Design complexity	1.00

71	Inadequate external access	11 External access	1.00
		13 Equipment intensive	0.50
		14 Buffer activity	1.00
72	Poor ground condtiions	01 High precipitation	0.80
		02 Low precipitation	0.80
		07 Ground conditions	1.00
		13 Equipment intensive	0.50
		14 Buffer activity	1.00
81	Unanticipated utilities	12 Labour intensive	1.00
		13 Equipment intensive	1.00
		14 Buffer activity	1.00
		18 Contract provision	1.00
95	Delay in awarding contract	14 Buffer activity	1.00
		15 Innovative methods	1.00
		16 Design changes	1.00
		18 Contract provision	1.00
		22 Design complexity	1.00

APPENDIX B ACTIVITY LEVEL ANALYSIS BY MANUAL COMPUTATION

Activity level analysis

Activity 1 at location 1 (010101)
Method used: MAX-MIN
Problem source (X_j): 15 Site not ready
Standard Strength:

		V_9	V_{11}	V_{12}	V_{13}	V_{14}	V_{16}	V_{17}	V_{18}	
X	[	1.0	1.0	1.0	1.0	1.0	1.0	0.5	1.0	]

System-derived data:
Critical activity
Percent_remaining_duration = 75%
Ground Condition = Poor
Manpower = insufficient
Amount of time-lost = 10
Amount of man-hours lost = 15
Total amount of time lost = 43
Total amount of man-hours lost = 54

Activity attributes:

		V_1	V_7	V_9	V_{10}	V_{12}	V_{13}	V_{17}	V_{18}	
010100	[	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	]

S(X, V) matrix:

		V_9	V_{12}	V_{13}	V_{17}	V_{18}	
X	[	1.0	1.0	1.0	0.5	1.0	]

T(V, Z) matrix:

		V_9	V_{12}	V_{13}	V_{17}	V_{18}	
4007	[	0	0	0	0	1.0	]
7003	[	0	0	0	0	1.0	]
5012	[	0	0	0	0	1.0	]
6003	[	0	0	0	0	1.0	]
4002	[	0	0	0	0	1.0	]
6001	[	0	0	0	0	1.0	]
3005	[	0	0	0.8	0	0	]

R1(X, Z):

		3.5	**4.2**	**4.7**	**5.12**	**6.1**	**6.3**	**7.3**	
X	**[**	**0.8**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**]**

Activity 1 at location 1 (010101)
Method used: MAX-MIN
Problem Source (X_j): 31 Insufficient/Incomplete drawing
Standard Strength:

		V_{12}	V_{13}	V_{14}	V_{15}	V_{16}	
X	[	1.0	1.0	1.0	1.0	1.0	]

System-derived data:

Critical activity
Percent_remaining_duration = 75%
Ground Condition = Poor
Manpower = insufficient
Amount of time-lost = 3
Amount of man-hours lost = 2
Total amount of time lost = 43
Total amount of man-hours lost = 54

Activity attributes:

		V_1	V_7	V_9	V_{10}	V_{12}	V_{13}	V_{17}	V_{18}	
010100	[	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	]

S(X, V) matrix:

		V_{12}	V_{13}	
X	[	1.0	1.0	]

T(V, Z) matrix:

		V_{12}	V_{13}	V_{14}	V_{15}	V_{16}	
4002	[	0	0	0.4	0	0.4	]
7002	[	0	0	1.0	0	1.0	]
7003	[	0	0	1.0	0	1.0	]
5009	[	0	0	1.0	0	1.0	]

R(X, Z):

		4.2	**5.9**	**7.2**	**7.3**	
X	**[**	**0.0**	**0.0**	**0.0**	**0.0**	**]**

Activity 1 at location 1 (010101)
Method used: MAX-MIN
Problem Source (X_j): 32 Drawing errors
Standard Strength:

		V_{14}	V_{16}	V_{17}	V_{18}	V_{19}	V_{20}	
X	[	1.0	1.0	1.0	1.0	1.0	1.0	]

System-derived data:
Critical activity
Percent_remaining_duration = 75%
Ground Condition = Poor
Manpower = insufficient
Amount of time-lost = 3
Amount of man-hours lost = 3
Total amount of time lost = 43
Total amount of man-hours lost = 54
Activity attributes:

		V_1	V_7	V_9	V_{10}	V_{12}	V_{13}	V_{17}	V_{18}	
010100	[	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	]

S(X, V) matrix:

		V_{17}	V_{18}	
X	[	1.0	1.0	]

T(V, Z) matrix:

		V_{14}	V_{16}	V_{17}	V_{18}	V_{19}	V_{20}	
5014	[	0	1.0	0	1.0	0	0	]
7002	[	0	1.0	0	1.0	0	0	]
4018	[	0	1.0	0	1.0	0	0	]
5012	[	0	0.75	0	0	0	0	]

R(X, Z):

		4.18	**5.14**	**7.02**	
X	**[**	**1.0**	**1.0**	**1.0**	**]**

Activity 1 at location 1 (010101)
Method used: MAX-MIN
Problem Source (X_j): 34 Conflicting information
Standard Strength:

		V_9	V_{10}	V_{12}	V_{13}	V_{14}	V_{16}	V_{18}	V_{19}	V_{20}	
X	[	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	]

System-derived data:
Critical activity
Percent_remaining_duration = 75%
Ground Condition = Poor
Manpower = insufficient
Amount of time-lost = 4
Amount of man-hours lost = 6
Total amount of time lost = 43
Total amount of man-hours lost = 54
Responsibility code for problem source = 30

Activity attributes:

		V_1	V_7	V_9	V_{10}	V_{12}	V_{13}	V_{17}	V_{18}	
010100	[	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	]

S(X, V) matrix:

		V_9	V_{10}	V_{12}	V_{13}	V_{18}	
X	[	1.0	1.0	1.0	1.0	1.0	]

T(V, Z) matrix:

		V_9	V_{10}	V_{12}	V_{13}	V_{14}	V_{16}	V_{18}	V_{19}	V_{20}	
5010	[	0	0	0	0	1.0	1.0	0	0	0	]
5009	[	0	0	1.0	0	0	1.0	1.0	0	1.0	]
5011	[	0	0	0	0	0	1.0	0	0	0	]
4018	[	0	0	1.0	0	0	1.0	1.0	0	0	]

5015	[	0	0	0.75	0.75	0	0.75	0	0	0	]
4018	[	0	0	0	0	0	0.60	0	0	0	]
6001	[	0	0	0	0	0	0	0.60	0	0	]

R(X, Z):

		4.18	**5.09**	**5.15**	**6.01**	
X	**[**	**1.0**	**1.0**	**0.75**	**0.6**	**]**

Activity 1 at location 1 (010101)
Method used: MAX-MIN
Problem Source (X_j): 41 Insufficient manpower
Standard Strength:

		V_{12}	V_{13}	V_{14}	
X	[	1.0	0.5	1.0	]

System-derived data:
- Critical activity
- Percent_remaining_duration = 75%
- Ground Condition = Poor
- Manpower = insufficient
- Amount of time-lost = 3
- Amount of man-hours lost = 3
- Total amount of time lost = 43
- Total amount of man-hours lost = 54
- Responsibility code for problem source = 30

Activity attributes:

		V_1	V_7	V_9	V_{10}	V_{12}	V_{13}	V_{17}	V_{18}	
010100	[	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	]

S(X, V) matrix:

		V_{12}	V_{13}	
X	[	1.0	0.5	]

T(V, Z) matrix:

		V_{12}	V_{13}	V_{14}	
2001	[	1.0	0	1.0	]

R(X, Z):

		2.01	
X	**[**	**1.0**	**]**

Activity 1 at location 1 (010101)
Method used: MAX-MIN
Problem Source (X_j): 44 Low Skill Level
Standard Strength:

		V_{12}	V_{13}	V_{14}	V_{15}	V_{20}	V_{22}	
X	[	1.0	0.5	1.0	1.0	1.0	1.0	]

System-derived data:
Critical activity
Percent_remaining_duration = 75%
Ground Condition = Poor
Manpower = insufficient
Amount of time-lost = 2
Amount of man-hours lost = 3
Total amount of time lost = 43
Total amount of man-hours lost = 54

Activity attributes:

		V_1	V_7	V_9	V_{10}	V_{12}	V_{13}	V_{17}	V_{18}	
010100	[	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	]

S(X, V) matrix:

		V_{12}	V_{13}	
X	[	1.0	0.5	]

T(V, Z) matrix:

		V_{12}	V_{13}	V_{14}	V_{15}	V_{20}	V_{22}	
2004	[	1.0	0	0	0	0	0	]
2009	[	1.0	0	0	0	0	0	]
2010	[	0.5	0	0	0	0	0	]
2011	[	0.7	0	0	0	0	0	]
2003	[	0.8	0	0	0	0	0	]
5002	[	0	0	0	0	0	0	]
5006	[	0	0	0	0	0	0	]

R(X, Z):

		2.3	**2.4**	**2.9**	**2.10**	**2.11**	
X	**[**	**0.8**	**1.0**	**1.0**	**0.5**	**0.7**	**]**

Activity 1 at location 1 (010101)
Method used: MAX-MIN
Problem Source (X_j): 46 Low motivation/moral
Standard Strength:

		V_1	V_3	V_5	V_{12}	V_{13}	V_{14}	V_{17}	V_{18}	V_{19}	V_{20}	
X	[	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	]

System-derived data:
Critical activity
Percent_remaining_duration = 75%
Ground Condition = Poor
Manpower = insufficient

Amount of time-lost = 4
Amount of man-hours lost = 4
Total amount of time lost = 43
Total amount of man-hours lost = 54

Activity attributes:

		V_1	V_7	V_9	V_{10}	V_{12}	V_{13}	V_{17}	V_{18}	
010100	[	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	]

S(X, V) matrix:

		V_1	V_{12}	V_{13}	V_{17}	V_{18}	
X	[	1.0	1.0	1.0	1.0	1.0	]

T(V, Z) matrix:

		V_1	V_3	V_5	V_{12}	V_{13}	V_{14}	V_{17}	V_{18}	V_{19}	V_{20}
2005	[	0	0	0	1.0	0	0	]			
2001	[	0	0	0	1.0	0	0	]			

R(X, Z):

		2.1	**2.5**	
X	**[**	**1.0**	**1.0**	**]**

Activity 1 at location 1 (010101)
Method used: MAX-MIN
Problem Source (X_j): 56 Error in construction
Standard Strength:

		V_9	V_{12}	V_{13}	V_{14}	V_{15}	V_{16}	V_{17}	V_{18}	V_{20}	V_{22}	
X	[	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	]

System-derived data:
Critical activity
Percent_remaining_duration = 75%
Ground Condition = Poor
Manpower = insufficient
Amount of time-lost = 5
Amount of man-hours lost = 7
Total amount of time lost = 43
Total amount of man-hours lost = 54
Frequency of occurrence = 2
Otheractivity(freefloat) = False

Activity attributes:

		V_1	V_7	V_9	V_{10}	V_{12}	V_{13}	V_{17}	V_{18}	
010100	[	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	]

S(X, V) matrix:

		V_9	V_{12}	V_{13}	V_{17}	V_{18}	
X	[	1.0	1.0	1.0	1.0	1.0	]

T(V, Z) matrix:

	V_9	V_{12}	V_{13}	V_{14}	V_{15}	V_{16}	V_{17}	V_{18}	V_{20}	V_{22}

5010	[	0	0	0	1.0	1.0	1.0	0	0	0	0]
4021	[	0	1.0	0	0	0	0	0	0	0	0]
5017	[	0	0	0	0	0	0	1.0	0	0	0]
4020	[	0	0	0	0	1.0	0	0	0	0	0]
5002	[	0	0	0	0	0	0	1.0	0	0	0]
7003	[	0	1.0	0	0	0	0	0	1.0	0	0]
5012	[	0	0	0	0	0	0	0	1.0	0	0]
5016	[	0	0	0	0	0	0	0	1.0	0	0]
4010	[	0	0	1.0	0	0	0	0	0	0	0]
4009	[	0	0	0.5	0	0	0	0	0	0	0]
2001	[	0	1.0	0	0	0	0	0	0	0	0]

R(X, Z):

		2.1	**4.09**	**4.10**	**4.21**	**5.2**	**5.12**	**5.16**	**5.17**	**7.03**	
X	**[**	**1.0**	**0.5**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**]**

Activity 1 at location 1 (010101)
Method used: MAX-MIN
Problem Source (X_j): 57 Layout error
Standard Strength:

		V_9	V_{10}	V_{12}	V_{16}	V_{17}	V_{18}	V_{22}	
X	[	1.0	1.0	1.0	1.0	1.0	1.0	1.0	]

System-derived data:
Critical activity
Percent_remaining_duration = 75%
Ground Condition = Poor
Manpower = insufficient
Amount of time-lost = 3
Amount of man-hours lost = 3
Total amount of time lost = 43
Total amount of man-hours lost = 54
Activity attributes:

		V_1	V_7	V_9	V_{10}	V_{12}	V_{13}	V_{17}	V_{18}	
010100	[	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	]

S(X, V) matrix:

		V_9	V_{10}	V_{12}	V_{17}	V_{18}	
X	[	1.0	1.0	1.0	1.0	1.0	]

T(V, Z) matrix:

		V_9	V_{10}	V_{12}	V_{16}	V_{17}	V_{18}	V_{22}	
5014	[	0	0	1.0	1.0	0	1.0	0	]
4015	[	0	0	1.0	1.0	0	1.0	0	]
4014	[	0	0	0	1.0	0	0	0	]
2002	[	0	0	0	1.0	0	0	0	]

R(X, Z):

		4.15	**5.14**	
X	**[**	**1.0**	**1.0**	**]**

Activity 1 at location 1 (010101)
Method used: MAX-MIN
Problem Source (X_j): 95 Delay in awarding contract
Standard Strength:

		V_{14}	V_{15}	V_{16}	V_{18}	V_{22}	
X	[	1.0	1.0	1.0	1.0	1.0	]

System-derived data:
- Critical activity
- Percent_remaining_duration = 75%
- Ground Condition = Poor
- Manpower = insufficient
- Amount of time-lost = 6
- Amount of man-hours lost = 8
- Total amount of time lost = 43
- Total amount of man-hours lost = 54
- Frequency of occurrence = 2

User input:
- Buffer activity in current time frame = Yes

Activity attributes:

		V_1	V_7	V_9	V_{10}	V_{12}	V_{13}	V_{17}	V_{18}	
010100	[	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	]

S(X, V) matrix:

		V_{18}	
X	[	1.0	]

T(V, Z) matrix:

		V_{12}	V_{13}	V_{14}	V_{15}	V_{16}	V_{18}	V_{22}	
6003	[	1.0	1.0	0	1.0	0	1.0	0	]
2002	[	1.0	0	0	0	0	0	0	]
2008	[	1.0	0	0	0	0	0	0	]
4010	[	0	0.75	0	0	0	0	0	]
4009	[	0	1.0	0	0	0	0	0	]
2008	[	1.0	0	0	0	0	0	0	]
4010	[	0	1.0	0	0	0	0	0	]

R(X, Z):

		6.3	
X	**[**	**1.0**	**]**

Activity level aggregation analysis

From Problem Source 15 we have

		3.5	4.2	4.7	5.12	6.1	6.3	7.3	
X	[	0.8	1.0	1.0	1.0	1.0	1.0	1.0	]

From Problem Source 31 we have

		0.0	
X	[	1.0	]

For problem source 32 we have

		4.18	5.14	7.02	
X	[	1.0	1.0	1.0	]

For problem source 34 we have

		4.18	5.09	5.15	6.01	
X	[	1.0	1.0	0.75	0.6	]

For problem source 41 we have

		2.01	
X	[	1.0	]

For problem source 44 we have

		2.3	2.4	2.9	2.10	2.11	
X	[	0.8	1.0	1.0	0.5	0.7	]

For problem source 46 we have

		2.1	2.5	
X	[	1.0	1.0	]

For problem source 56 we have

		2.1	4.09	4.10	4.21	5.2	5.12	5.16	5.17	7.03	
X	[	1.0	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	]

For problem source 57 we have

		4.15	5.14	
X	[	1.0	1.0	]

For problem source 95 we have

		6.3	
X	[	1.0	]

Renormalized each of them, we have,

		3.5	4.2	4.7	5.12	6.1	6.3	7.3	
15	[	0.118	0.147	0.147	0.147	0.147	0.147	0.147	]

		0.0							
31	[	1.0	]						
		4.18	5.14	7.02					
32	[	0.333	0.333	0.334	]				
		4.18	5.09	5.15	6.01				
34	[	0.30	0.30	0.22	0.18	]			
		2.01							
41	[	1.0	]						
		2.3	2.4	2.9	2.10	2.11			
44	[	0.20	0.25	0.25	0.125	0.175	]		
		2.1	2.5						
46	[	0.5	0.5	]					
		2.2	4.09	4.10	4.21	5.2	5.12	5.16	5.17	7.03
56	[	0.1176	0.1176	0.0592	0.1176	0.1176	0.1176	0.1176	0.1176	0.1176]
		4.15	5.14						
57	[	0.5	0.5	]					
		6.3							
95	[	1.0	]						

(i) Weights determined by frequency of occurrence are:

W_k:

$W_{15} = 1/12 = 0.0833$
$W_{31} = 1/12 = 0.0833$
$W_{32} = 1/12 = 0.0833$
$W_{34} = 1/12 = 0.0833$
$W_{41} = 1/12 = 0.0833$
$W_{44} = 1/12 = 0.0833$
$W_{46} = 1/12 = 0.0833$
$W_{56} = 2/12 = 0.1667$
$W_{57} = 1/12 = 0.0833$
$W_{95} = 2/12 = 0.1633$

Therefore,

when renormalized each of them, we have,

$$
\begin{array}{lllllllllllllll}
 & & & 3.5 & 4.2 & 4.7 & 5.12 & 6.1 & 6.3 & 7.3 & & & & & \\
Z = & 0.0833 \times [& & 0.118 & 0.147 & 0.147 & 0.147 & 0.147 & 0.147 & 0.147 &] + & & & & \\
 & & & 0.0 & & & & 4.18 & 5.14 & 7.02 & & & & & \\
 & 0.0833 \times [& & 1.0 &] + & 0.0833 \times [& & 0.333 & 0.333 & 0.334 &] + & & & & \\
 & & & 4.18 & 5.09 & 5.15 & 6.01 & & & & & 2.01 & & & \\
 & 0.0833 \times [& & 0.30 & 0.30 & 0.22 & 0.18 &] + 0.0833 \times [& & & & 1.0 &] + & & \\
 & & & 2.3 & 2.4 & 2.9 & 2.10 & 2.11 & & & & & 2.1 & 2.5 & \\
 & 0.0833 \times [& & 0.20 & 0.25 & 0.25 & 0.125 & 0.175 &] + 0.0833 \times [& & & & 0.5 & 0.5] + & \\
 & & & 2.1 & 4.09 & 4.10 & 4.21 & 5.2 & 5.12 & 5.16 & 5.17 & 7.03 & & & \\
 & 0.1667 \times [& & 0.1176 & 0.0592 & 0.1176 & 0.1176 & 0.1176 & 0.1176 & 0.1176 & 0.1176 & 0.1176 &] + & & \\
 & & & 4.15 & 5.14 & & & 6.3 & & & & & & & \\
 & 0.0833 \times [& & 0.5 & 0.5] + 0.1667 \times [& & & 1.0 &] & & & & & & &
\end{array}
$$

and

$$
\begin{array}{lllllllllllll}
 & & 0.0 & 2.1 & 2.3 & 2.4 & 2.5 & 2.9 & 2.10 & 2.11 & 3.5 & 4.2 & \\
Z = & [& 0.0833 & 0.1446 & 0.0167 & 0.021 & 0.0417 & 0.0208 & 0.0104 & 0.0146 & 0.01 & 0.0122 & + \\
 & & 4.7 & 4.9 & 4.10 & 4.15 & 4.18 & 4.21 & 5.2 & 5.9 & 5.12 & 5.14 & 5.15 \\
 & & 0.0122 & 0.01 & 0.0196 & 0.042 & 0.0527 & 0.0196 & 0.0196 & 0.025 & 0.0318 & 0.0694 & 0.0186 + \\
 & & 5.16 & 5.17 & 6.1 & 6.3 & 7.2 & 7.3 & & & & & \\
 & & 0.0196 & 0.0196 & 0.0272 & 0.1789 & 0.0278 & 0.0318 &] & & & &
\end{array}
$$

Activity Compatibility Matrix for Manual Calculation

	0	2.1	2.3	2.4	2.5	2.9	2.10	2.11	3.5	4.2	4.7	4.9	4.10	4.15	4.16	4.21	5.2	5.9	5.12	5.14	5.15	5.16	5.17	6.1	6.3	7.2	7.3
0	1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
2.1	-1	1	0	0	-1	0	-1	0	-1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.3	-1	0	1	0	0	1	-1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
2.4	-1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.5	-1	-1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.9	-1	0	1	1	0	1	-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
2.10	-1	-1	-1	1	0	-1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.11	-1	0	1	0	0	-1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5	-1	-1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0
4.2	-1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1
4.7	-1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
4.9	-1	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.10	-1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.15	-1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	1	0	0	0	0	0
4.16	-1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	1	1	1	0	1	0	1	0
4.21	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0
5.2	-1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
5.9	-1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	1	0	0	0	1	0
5.12	-1	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	1	0	0	0	0	1	1	0	1
5.14	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	1	0	1	0	1	0
5.15	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0
5.16	-1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	1	1	1	0	0	1	1	0
5.17	-1	0	0	0	0	1	0	0	-1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1
6.1	-1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	1	0	0	0	1	1	0	1
6.3	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	1	0	0
7.2	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	1	0	0	0	1	0
7.3	-1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	1

The resulted aggregation runs are equal:

	Original Data	1st run	Rearranged Data 1	2nd run	Rearrange Data 2	3rd run	Rearranged Data 3	4th run	Rearranged Data 4	5th run
0.0	0.0833	-0.8338	0	-1.0004	0	-1.0004	0	-1.0004	0	-1.0004
2.1	0.1446	0.0288	0.1446	0.1121	0.1446	0.1221	0.1446	0.1325	0.1446	0.1742
2.3	0.0167	-0.022	0.0167	0.0613	0.0167	0.0613	0.0167	0.0717	0.0167	0.0717
2.4	0.021	0.0106	0.021	0.0939	0.021	0.0939	0.021	0.0835	0.021	0.0418
2.5	0.0417	-0.1652	0.0417	-0.0819	0.0417	-0.0819	0.0417	-0.0819	0	-0.1236
2.9	0.0208	-0.0302	0.0208	0.0531	0.0208	0.0531	0.0208	0.0635	0.0208	0.0635
2.10	0.0104	-0.2194	0.0104	-0.1361	0.0104	-0.1361	0	-0.1465	0	-0.1465
2.11	0.0146	-0.0624	0.0146	0.0209	0.0146	0.0209	0.0146	0.0105	0.0146	0.0105
3.5	0.01	-0.2375	0.01	-0.1542	0	-0.1642	0	-0.1642	0	-0.1642
4.2	0.0122	0.0419	0.0122	0.1252	0.0122	0.1252	0.0122	0.1252	0.0122	0.1252
4.7	0.0122	-0.0271	0.0122	0.0562	0.0122	0.0562	0.0122	0.0562	0.0122	0.0562
4.9	0.01	0.0835	0.01	0.1668	0.01	0.1668	0.01	0.1668	0.01	0.1668
4.10	0.0196	0.0809	0.0196	0.1642	0.0196	0.1642	0.0196	0.1642	0.0196	0.1642
4.15	0.042	0.056	0.042	0.2226	0.042	0.2326	0.042	0.243	0.042	0.2847
4.18	0.0527	0.2447	0.0527	0.4113	0.0527	0.4213	0.0527	0.4317	0.0527	0.4734
4.21	0.0196	0.0086	0.0196	0.0919	0.0196	0.0919	0.0196	0.0919	0.0196	0.0919
5.2	0.0196	0.0057	0.0196	0.089	0.0196	0.089	0.0196	0.089	0.0196	0.089
5.9	0.025	0.1005	0.025	0.2671	0.025	0.2771	0.025	0.2875	0.025	0.3292
5.12	0.0318	0.2635	0.0318	0.3468	0.0318	0.3468	0.0318	0.3468	0.0318	0.3468
5.14	0.0694	0.1384	0.0694	0.305	0.0694	0.315	0.0694	0.3254	0.0694	0.3671
5.15	0.0183	0.0073	0.0183	0.1739	0.0183	0.1839	0.0183	0.1943	0.0183	0.236
5.16	0.0196	0.3504	0.1029	0.517	0.1129	0.527	0.1233	0.5374	0.165	0.5791
5.17	0.0196	-0.0015	0.0196	0.0818	0.0196	0.0918	0.0196	0.0918	0.0196	0.0918
6.1	0.0272	0.3207	0.0272	0.404	0.0272	0.404	0.0272	0.404	0.0272	0.404
6.3	0.1789	0.1742	0.1789	0.3408	0.1789	0.3508	0.1789	0.3612	0.1789	0.4029
7.2	0.0278	0.1112	0.0278	0.2778	0.0278	0.2878	0.0278	0.2982	0.0278	0.3399
7.3	0.0318	0.0393	0.0318	0.1226	0.0318	0.1226	0.0318	0.1226	0.0318	0.1226

The Rearranged Data 4 represented the final output data for aggregating corrective actions according to frequency of occurrence.

The following pages show the aggregating corrective actions routine by manhours and time losts.

Aggregating corrective actions by manhours lost

	15	31	32	34	41	44	46	56	57	95
MHL	15	2	3	6.0000	3.0000	3.0000	4.0000	7.0000	3.0000	8.0000
W	0.2778	0.0370	0.0556	0.1111	0.0556	0.0556	0.0741	0.1296	0.0556	0.1481

	Orig. Data*W	Coeff.	Rearr. Data 1	Coeff.	Rearr. Data 2	Coeff.	Rearr. Data 3	4th run	Rearr. Data 4	5th run
0.0	0.0370	-0.9259	0.0000	-1.0000	0.0000	-1.0000	0.0000	-1.0000	0.0000	-1.0000
2.1	0.1078	0.0170	0.1078	0.0541	0.1078	0.0610	0.1078	0.0937	0.1078	0.1307
2.3	0.0111	0.0060	0.0111	0.0430	0.0111	0.0500	0.0111	0.0500	0.0111	0.0500
2.4	0.0139	0.0347	0.0139	0.0718	0.0139	0.0648	0.0139	0.0648	0.0139	0.0278
2.5	0.0370	-0.0940	0.0370	-0.0569	0.0370	-0.0569	0.0370	-0.0569	0.0000	-0.0940
2.9	0.0139	0.0004	0.0139	0.0375	0.0139	0.0444	0.0139	0.0444	0.0139	0.0444
2.10	0.0069	-0.1393	0.0069	-0.1023	0.0000	-0.1092	0.0000	-0.1092	0.0000	-0.1092
2.11	0.0097	-0.0231	0.0097	0.0139	0.0097	0.0069	0.0097	0.0069	0.0097	0.0069
3.5	0.0327	-0.1275	0.0327	-0.0904	0.0327	-0.0904	0.0000	-0.1231	0.0000	-0.1231
4.2	0.0408	0.2252	0.0408	0.2993	0.0408	0.3063	0.0408	0.3389	0.0408	0.3760
4.7	0.0408	0.1008	0.0408	0.1378	0.0408	0.1378	0.0408	0.1378	0.0408	0.1378
4.9	0.0076	0.1193	0.0076	0.1563	0.0076	0.1563	0.0076	0.1563	0.0076	0.1563
4.10	0.0153	0.0861	0.0153	0.1231	0.0153	0.1231	0.0153	0.1231	0.0153	0.1231
4.15	0.0278	0.0908	0.0278	0.1279	0.0278	0.1279	0.0278	0.1279	0.0278	0.1279
4.18	0.0517	0.2947	0.0517	0.3688	0.0517	0.3757	0.0517	0.4084	0.0517	0.4455
4.21	0.0153	0.0452	0.0153	0.0822	0.0153	0.0822	0.0153	0.0822	0.0153	0.0822
5.2	0.0153	0.0410	0.0153	0.0780	0.0153	0.0780	0.0153	0.0780	0.0153	0.0780
5.9	0.0332	0.1040	0.0332	0.1410	0.0332	0.1410	0.0332	0.1410	0.0332	0.1410
5.12	0.0561	0.4583	0.0561	0.5324	0.0561	0.5393	0.0561	0.5720	0.0561	0.6090
5.14	0.0463	0.1886	0.0463	0.2627	0.0463	0.2697	0.0463	0.3023	0.0463	0.3394
5.15	0.0249	0.0548	0.0249	0.0918	0.0249	0.0918	0.0249	0.0918	0.0249	0.0918
5.16	0.0153	0.3695	0.0153	0.4066	0.0153	0.4066	0.0153	0.4066	0.0153	0.4066
5.17	0.0153	0.0308	0.0153	0.0678	0.0153	0.0678	0.0153	0.1005	0.0153	0.1005
6.1	0.0608	0.4637	0.0978	0.5378	0.1047	0.5448	0.1374	0.5774	0.1744	0.6145
6.3	0.1890	0.2841	0.1890	0.3581	0.1890	0.3651	0.1890	0.3978	0.1890	0.4348
7.2	0.0185	0.1279	0.0185	0.1649	0.0185	0.1649	0.0185	0.1649	0.0185	0.1649
7.3	0.0561	0.1920	0.0561	0.2661	0.0561	0.2730	0.0561	0.3057	0.0561	0.3427

The rearranged data 4 displayed the end results of the aggregating routine using manhours lost criterion.

Aggregating corrective actions by time lost at activity level

	15	31	32	34	41	44	46	56	57	95
TL	10	3	3	4	3	2	4	5	3	6
W	0.2326	0.0698	0.0698	0.0930	0.0698	0.0465	0.0930	0.1163	0.0698	0.1395

	Orig. Data * W	Coeff.	Rearr. Data 1	Coeff.	Rearr. Data 2	Coeff.	Rearr. Data 3	4th run	Rearr. Data 4	5th run
0.0	0.0698	-0.8605	0.0000	-1.0000	0.0000	-1.0000	0.0000	-1.0000	0.0000	-1.0000
2.1	0.1300	0.0010	0.1300	0.0708	0.1300	0.0766	0.1300	0.1040	0.1300	0.1505
2.3	0.0093	-0.0328	0.0093	0.0369	0.0093	0.0427	0.0093	0.0427	0.0093	0.0427
2.4	0.0116	0.0058	0.0116	0.0756	0.0116	0.0698	0.0116	0.0698	0.0116	0.0233
2.5	0.0465	-0.1416	0.0465	-0.0718	0.0465	-0.0718	0.0465	-0.0718	0.0000	-0.1183
2.9	0.0116	-0.0375	0.0116	0.0323	0.0116	0.0381	0.0116	0.0381	0.0116	0.0381
2.10	0.0058	-0.1951	0.0058	-0.1253	0.0000	-0.1311	0.0000	-0.1311	0.0000	-0.1311
2.11	0.0081	-0.0581	0.0081	0.0116	0.0081	0.0058	0.0081	0.0058	0.0081	0.0058
3.5	0.0274	-0.1860	0.0274	-0.1163	0.0274	-0.1163	0.0000	-0.1436	0.0000	-0.1436
4.2	0.0342	0.1521	0.0342	0.2916	0.0342	0.2974	0.0342	0.3248	0.0342	0.3713
4.7	0.0342	0.0465	0.0342	0.1163	0.0342	0.1163	0.0342	0.1163	0.0342	0.1163
4.9	0.0068	0.1012	0.0068	0.1710	0.0068	0.1710	0.0068	0.1710	0.0068	0.1710
4.10	0.0137	0.0739	0.0137	0.1436	0.0137	0.1436	0.0137	0.1436	0.0137	0.1436
4.15	0.0349	0.0576	0.0349	0.1274	0.0349	0.1274	0.0349	0.1274	0.0349	0.1274
4.18	0.0510	0.2581	0.0510	0.3977	0.0510	0.4035	0.0510	0.4309	0.0510	0.4774
4.21	0.0137	0.0086	0.0137	0.0784	0.0137	0.0784	0.0137	0.0784	0.0137	0.0784
5.2	0.0137	0.0042	0.0137	0.0740	0.0137	0.0740	0.0137	0.0740	0.0137	0.0740
5.9	0.0278	0.0880	0.0278	0.1577	0.0278	0.1577	0.0278	0.1577	0.0278	0.1577
5.12	0.0479	0.3700	0.0479	0.5095	0.0479	0.5154	0.0479	0.5427	0.0479	0.5892
5.14	0.0581	0.1550	0.0581	0.2945	0.0581	0.3003	0.0581	0.3277	0.0581	0.3742
5.15	0.0208	0.0158	0.0208	0.0855	0.0208	0.0855	0.0208	0.0855	0.0208	0.0855
5.16	0.0137	0.3335	0.0137	0.4033	0.0137	0.4033	0.0137	0.4033	0.0137	0.4033
5.17	0.0137	-0.0103	0.0137	0.0595	0.0137	0.0595	0.0137	0.0869	0.0137	0.0869
6.1	0.0509	0.3940	0.1206	0.5335	0.1264	0.5393	0.1538	0.5667	0.2003	0.6132
6.3	0.1737	0.2164	0.1737	0.3559	0.1737	0.3617	0.1737	0.3891	0.1737	0.4356
7.2	0.0233	0.1041	0.0233	0.1739	0.0233	0.1739	0.0233	0.1739	0.0233	0.1739
7.3	0.0479	0.1247	0.0479	0.2643	0.0479	0.2701	0.0479	0.2974	0.0479	0.3440

The rearranged data 4 displayed the end results of the aggregating routine using time lost as weighting criterion.

APPENDIX C TRADE LEVEL ANALYSIS BY MANUAL CALCULATION

Trade: 01
Method used: MAX-MIN
Weighting criterion: Frequency of occurrence
Problem source (X_j): 34 Conflicting information
Standard Strength:

		V_9	V_{10}	V_{12}	V_{13}	V_{14}	V_{16}	V_{18}	V_{19}	V_{20}	
X	[	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	]

System-derived data:

Dispersion index = 2/5 = 0.4
Percent_critical = 3/5*100 = 60%
Trade(Percent_remaining_duration) = (7+2/10 + 8+3/9)/20*100 = 77.67%
Ground Condition = Fair
Manpower = insufficient
Manpower(skill) = Fair
Critical activity day lost = 12.9
Amount of time-lost = 2.5
Amount of man-hours lost = 5
Total amount of time lost = 18.2
Total amount of man-hours lost = 56

Trade attributes:

		V_1	V_7	V_9	V_{10}	V_{12}	V_{13}	V_{16}	V_{17}	V_{18}	V_{20}		
Trade 01		[	0.6	0.6	1.0	0.6	0.4	0.6	0.4	1.0	0.4	0.4	]

S(X, V) matrix:

		V_9	V_{10}	V_{12}	V_{13}	V_{16}	V_{18}	V_{20}	
X	[	1.0	0.6	0.4	0.6	0.4	0.4	0.4	]

T(V, Z) matrix:

		V_9	V_{10}	V_{12}	V_{13}	V_{14}	V_{15}	V_{16}	V_{18}	V_{19}	V_{20}	
2008	[	0	0	0	0	0	0	0.7	0.28	0	0.28	]
2004	[	0	0	0	0	0	0	0	0.7	0	0	]
2006	[	0	0	0.5	0	0	0	0	0	0	0	]
2007	[	0	0	0.5	0	0	0	0.28	0	0	0	]
2001	[	0	0	0	0	0	0	0	0	0	0.28	]
1003	[	0	0	0	0	0	0.5	0	0	0	0	]
2002	[	0	0	0	0	0	0	0	0.5	0	0	]

R(X, Z):

		2.1	**2.2**	**2.4**	**2.6**	**2.7**	**2.8**	
X	**[**	**0.28**	**0.4**	**0.4**	**0.4**	**0.4**	**0.4**	**]**

Trade: 01
Method used: MAX-MIN
Weighting criterion: Frequency of occurrence
Problem source (X_j): 41 Undermanning
Standard Strength:

		V_{12}	V_{13}	V_{14}	
X	[	1.0	0.5	1.0	]

System-derived data:

Dispersion index = 5/5 = 1.0
trade_percent_critical = 3/5*100 = 60%
Percent_remaining_duration = 77.67%
Ground Condition = Fair
Site access = Fair
Manpower = insufficient
Critical activity day lost = 12.9
Amount of time-lost = 14.10
Amount of man-hours lost = 22.00
Total amount of time lost = 18.2
Total amount of man-hours lost = 56

Trade attributes:

		V_1	V_7	V_9	V_{10}	V_{12}	V_{13}	V_{16}	V_{17}	V_{18}	V_{20}	
Trade 01	[	0.6	0.6	1.0	0.6	0.4	0.6	0.4	1.0	0.4	0.4	]

S(X, V) matrix:

		V_{12}	V_{13}	
X	[	0.4	0.3	]

T(V, Z) matrix:

		V_9	V_{12}	V_{13}	V_{16}	V_{17}	V_{18}	V_{20}	
1001	[	0	1.0	0	0	0	0	0	]
2003	[	0	1.0	0	0	0	0	0	]
1003	[	0	0.5	0	0	0	0	0	]
1004	[	0.5	0	0	0	0	0	0	]
2002	[	0	0.2	0.5	0	0	0	0	]
2004	[	0	1.0	0	0	0	1.0	0	]

R(X, Z):

		1.1	**1.3**	**2.2**	**2.3**	**2.4**	
X	**[**	**0.4**	**0.4**	**0.3**	**0.4**	**0.4**	**]**

Trade: 01
Method used: MAX-MIN
Weighting criterion: Frequency of occurrence
Problem source (X_j): 56 Construction Error
Standard Strength:

		V_9	V_{12}	V_{13}	V_{14}	V_{15}	V_{16}	V_{17}	V_{18}	V_{20}	V_{22}	
X	[	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	]

System-derived data:

Dispersion index = 2/5 = 0.4

Trade percent_critical = 3/5*100 = 60%
Percent_remaining_duration = 77.67%
Ground Condition = Fair
Site access = Fair
Manpower = insufficient
Manpower(skill) = Fair
Critical activity time lost = 12.9
Amount of time-lost = 0.1
Amount of man-hours lost = 15
Total amount of time lost = 18.2
Total amount of man-hours lost = 56
Site(access) = Fair

Trade attributes:

		V_1	V_7	V_9	V_{10}	V_{12}	V_{13}	V_{16}	V_{17}	V_{18}	V_{20}	
Trade 01	[	0.6	0.6	1.0	0.6	0.4	0.6	0.4	1.0	0.4	0.4	]

S(X, V) matrix:

		V_9	V_{12}	V_{13}	V_{16}	V_{17}	V_{18}	V_{20}	
X	[	1.0	0.4	0.6	0.4	1.0	0.4	0.4	]

T(V, Z) matrix:

		V_9	V_{12}	V_{13}	V_{14}	V_{15}	V_{16}	V_{17}	V_{18}	V_{20}	V_{22}	
2001	[	0	0	0	0	0	0	0	0.28	0	0	]
2005	[	0.5	0.5	0	0	0	0	0	0.5	0	0	]
1005	[	0	0.8	0	0	0	0	0	0	0	0	]
1003	[	0	0.5	0	0	0	0	0	0	0	0	]
1004	[	0.5	0	0	0	0	0	0	0	0	0	]
2002	[	0	0.20	0	0	0	0	0	0.5	0	0	]

R(X, Z):

		1.3	**1.4**	**1.5**	**2.1**	**2.2**	**2.5**	
X	**[**	**0.4**	**0.5**	**0.4**	**0.28**	**0.4**	**0.5**	**]**

Trade: 02
Method used: MAX-MIN
Weighting criterion: Frequency of occurrence
Problem source (X_j): 34 Conflicting information
Standard Strength:

		V_9	V_{10}	V_{12}	V_{13}	V_{14}	V_{16}	V_{18}	V_{19}	V_{20}	
X	[	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	]

System-derived data:
Dispersion index = 1/1 = 1.0
Trade percent_critical = 0/1*100% = 0%
Percent_remaining_duration = (3/9 /10)* 100% = 93.33%
Ground Condition = Fair
Site access = Fair

Manpower = sufficient
Manpower(skill) = Fair
Critical activity time lost = 0
Amount of time-lost = 1.3
Amount of man-hours lost = 13
Total amount of time lost = 1.7
Total amount of man-hours lost = 16
Site(access) = Fair

Trade attributes:

	V_3	V_8	V_9	V_{10}	V_{12}	V_{16}	V_{18}	V_{19}	V_{20}		
Trade 02	[	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	]

S(X, V) matrix:

		V_9	V_{10}	V_{12}	V_{16}	V_{18}	V_{19}	V_{20}	
X	[	1.0	1.0	1.0	1.0	1.0	1.0	1.0	]

T(V, Z) matrix:

		V_{12}	V_{15}	V_{16}	V_{18}	V_{20}	
2008	[	0	0	0	1.0	0.5	]
2007	[	0.7	0	1.0	0	0	]
2006	[	0.7	0	0	0	0	]
2001	[	0	0	0	0	0.5	]
2004	[	0	0	0	1.0	1.0	]
1003	[	0	0.5	0	0	0	]
2002	[	0	0	0	0.5	0	]

R(X, Z):

		2.1	**2.2**	**2.4**	**2.6**	**2.7**	**2.8**	
X	**[**	**0.5**	**0.5**	**1.0**	**0.7**	**1.0**	**1.0**	**]**

Trade: 02
Method used: MAX-MIN
Weighting criterion: Frequency of occurrence
Problem source (X_j): 41 Undermanning
Standard Strength:

		V_{12}	V_{13}	V_{14}	
X	[	1.0	0.5	1.0	]

System-derived data:
Dispersion index = 1/1 = 1.0
Trade percent_critical = 0/1*100% = 0%
Percent_remaining_duration = 93.33%
Ground Condition = Fair
Site access = Fair
Manpower = sufficient
Manpower(skill) = Fair
Critical activity time lost = 0
Amount of time-lost = 0.4
Amount of man-hours lost = 3

Total amount of time lost = 1.7
Total amount of man-hours lost = 16
Site(access) = Fair

Trade attributes:

		V_3	V_8	V_9	V_{10}	V_{12}	V_{16}	V_{18}	V_{19}	V_{20}	
Trade 02	[	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	]

S(X, V) matrix:

		V_{12}	
X	[	1.0	]

T(V, Z) matrix:

		V_9	V_{12}	V_{13}	V_{18}	
1001	[	0	1.0	0	0	]
2003	[	0	1.0	0	0	]
1003	[	0	0.5	0	0	]
1004	[	0.5	0	0	0	]
2004	[	0	0.5	0	0.5	]
2002	[	0	0	0.5	0	]

R(X, Z):

		1.1	**1.3**	**2.3**	**2.4**	
X	**[**	**1.0**	**0.5**	**1.0**	**0.5**	**]**

AGGREGATION ROUTINE FOR TRADE LEVEL ANALYSIS

Trade: 01

Weighting criterion: Frequency of occurrence

Weight distributions determine by frequency of occurrence are:

$W_{34} = 2/25 = 0.08$
$W_{41} = 17/25 = 0.68$
$W_{56} = 4/25 = 0.16$
$W_{32} = 1/25 = 0.04$
$W_{46} = 1/25 = 0.04$

Calculate Dispersion Index as:

$DI_{34} = 0.4$
$DI_{41} = 1.0$
$DI_{56} = 0.4$
$DI_{32} = 0.2$

$DI_{46} = 0.2$

Calculate modified weight as:

$W_{34} * DI_{34}$	=	0.032
$W_{41} * DI_{41}$	=	0.68
$W_{56} * DI_{56}$	=	0.064
$W_{32} * DI_{32}$	=	0.008
$W_{46} * DI_{46}$	=	0.008

		0.792

Renormalized modified weight, we have:

$W^*_{34} = 0.0404$
$W^*_{41} = 0.8586$
$W^*_{56} = 0.0808$
$W^*_{32} = 0.0101$
$W^*_{46} = 0.0101$

When multiply each of them with the corrective actions, we have:

		2.1	2.2	2.4	2.6	2.7	2.8	
Z =	0.0404 x [	0.1228	0.1754	0.1754	0.1754	0.1754	0.1754	] +
		1.1	1.3	2.2	2.3	2.4		
	0.8586 x [	0.21	0.21	0.16	0.21	0.21	] +	
		1.3	1.4	1.5	2.1	2.2	2.5	
	0.0808 x [	0.1613	0.2016	0.1613	0.1129	0.1613	0.2016	] +
		0.0			0.0			
	0.0101 x [	1.0] +	0.0101 x [		1.0]			

Trade compatibility matrix coefficients for the corrective actions are:

Trade level aggregation level													
	0.0	**1.1**	**1.3**	**1.4**	**1.5**	**2.1**	**2.2**	**2.3**	**2.4**	**2.5**	**2.6**	**2.7**	**2.8**
0.0	1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1.1	-1	1	-1	0	1	0	0	1	0	0	0	0	1
1.3	-1	-1	1	0	-1	1	1	0	0	0	0	0	0
1.4	-1	0	0	1	-1	0	0	0	0	0	1	1	0
1.5	-1	1	-1	-1	1	1	1	0	0	0	0	0	1
2.1	-1	0	1	0	1	1	1	1	0	0	0	0	0
2.2	-1	0	1	0	1	1	1	0	0	1	1	0	0
2.3	-1	1	0	0	0	1	0	1	0	0	1	0	0
2.4	-1	0	0	0	0	0	0	0	1	0	0	0	0
2.5	-1	0	0	0	0	0	1	0	0	1	0	0	1
2.6	-1	0	0	1	0	0	1	1	0	0	1	0	0
2.7	-1	0	0	1	0	0	0	0	0	0	0	1	1
2.8	-1	1	0	0	1	0	0	0	0	1	0	1	1

The calculation for the compatibility factor routine at trade level using frequency of occurrence of problem sources is as follows:

	Original	**Coeff.**	**2nd Run**	**Coeff.**
	Data			
0.0	0.0202	-0.95959	0	-0.99999
1.1	0.180306	0.167192	0.180306	0.187392
1.3	0.193339	0.151379	0.193339	0.191779
1.4	0.016289	-0.00277	0.016289	0.017429
1.5	0.013033	0.142176	0.013033	0.182576
2.1	0.014083	0.538057	0.034283	0.578457
2.2	0.157495	0.381126	0.157495	0.421526

2.3	0.180306	0.361582	0.180306	0.401982
2.4	0.187392	0.167192	0.187392	0.187392
2.5	0.016289	0.160671	0.016289	0.180871
2.6	0.007086	0.340977	0.007086	0.361177
2.7	0.007086	0.010262	0.007086	0.030462
2.8	0.007086	0.203601	0.007086	0.223801

Trade level manual calculations using manhours lost criterion

Problem Source	DI	Manhours Lost	W	W*DI	Normalized W*DI
32	0.2	4	0.071429	0.014286	0.02439
34	0.4	5	0.089286	0.035714	0.060976
41	1	22	0.392857	0.392857	0.670732
46	0.2	10	0.178571	0.035714	0.060976
56	0.4	15	0.267857	0.107143	0.182927
Sum =		56	1	0.585714	1
Original Data					
	32	34	41	46	56
0.0	1	0	0	1	0
1.1	0	0	0.4	0	0
1.3	0	0	0.4	0	0.4
1.4	0	0	0	0	0.5
1.5	0	0	0	0	0.4
2.1	0	0.28	0	0	0.28
2.2	0	0.4	0.3	0	0.4
2.3	0	0	0.4	0	0

2.4	0	0.4	0.4	0	0
2.5	0	0	0	0	0.5
2.6	0	0.4	0	0	0
2.7	0	0.4	0	0	0
2.8	0	0.4	0	0	0

Normalized Strengths

	32	34	41	46	56
0.0	1	0	0	1	0
1.1	0	0	0.210526	0	0
1.3	0	0	0.210526	0	0.16129
1.4	0	0	0	0	0.201613
1.5	0	0	0	0	0.16129
2.1	0	0.122807	0	0	0.112903
2.2	0	0.175439	0.157895	0	0.16129
2.3	0	0	0.210526	0	0
2.4	0	0.175439	0.210526	0	0
2.5	0	0	0	0	0.201613
2.6	0	0.175439	0	0	0
2.7	0	0.175439	0	0	0
2.8	0	0.175439	0	0	0
Sum =	1	1	1	1	1

Compatibility Matrix calculations

	1st Data	Coeff.	2nd Data	Coeff.	
0.0	0.085366	-0.82927	0	-1	
1.1	0.141207	0.066538	0.141207	0.151904	

1.3	0.170711	0.088882	0.170711	0.259614	
1.4	0.03688	-0.05659	0.03688	0.028771	
1.5	0.029504	0.062699	0.029504	0.233431	
2.1	0.028141	0.430304	0.113507	0.601036	
2.2	0.146107	0.336675	0.146107	0.507407	
2.3	0.141207	0.235886	0.141207	0.406618	
2.4	0.151904	0.066538	0.151904	0.151904	
2.5	0.03688	0.108319	0.03688	0.193685	
2.6	0.010697	0.249526	0.010697	0.334891	
2.7	0.010697	-0.02709	0.010697	0.058275	
2.8	0.010697	0.143621	0.010697	0.228986	

Trade level manual calculations using time lost criterion

By Time Lost					
Problem Source	DI	Time Lost	W	W*DI	Normalized W*DI
32	0.2	1	0.054945	0.010989	0.012953
34	0.4	2.5	0.137363	0.054945	0.064767
41	1	14.1	0.774725	0.774725	0.913212
46	0.2	0.5	0.027473	0.005495	0.006477
56	0.4	0.1	0.005495	0.002198	0.002591
Sum =		18.2	1	0.848352	1

Original Data					
	32	34	41	46	56
0.0	1	0	0	1	0
1.1	0	0	0.4	0	0
1.3	0	0	0.4	0	0.4
1.4	0	0	0	0	0.5
1.5	0	0	0	0	0.4
2.1	0	0.28	0	0	0.28
2.2	0	0.4	0.3	0	0.4
2.3	0	0	0.4	0	0
2.4	0	0.4	0.4	0	0
2.5	0	0	0	0	0.5
2.6	0	0.4	0	0	0
2.7	0	0.4	0	0	0
2.8	0	0.4	0	0	0
Sum =	1	2.28	1.9	1	2.48

Normalized Strengths					
	32	34	41	46	56
0.0	1	0	0	1	0
1.1	0	0	0.210526	0	0
1.3	0	0	0.210526	0	0.16129
1.4	0	0	0	0	0.201613
1.5	0	0	0	0	0.16129
2.1	0	0.122807	0	0	0.112903
2.2	0	0.175439	0.157895	0	0.16129
2.3	0	0	0.210526	0	0
2.4	0	0.175439	0.210526	0	0
2.5	0	0	0	0	0.201613
2.6	0	0.175439	0	0	0
2.7	0	0.175439	0	0	0
2.8	0	0.175439	0	0	0
Sum =	1	1	1	1	1

Compatibility matrix routine				
	1st Data	Coeff.	2nd Data	Coeff.
0.0	0.01943	-0.96114	0	-1
1.1	0.192255	0.184188	0.192255	0.203618
1.3	0.192673	0.144788	0.192673	0.183648
1.4	0.000522	0.0034	0.000522	0.02283
1.5	0.000418	0.155628	0.000418	0.194489
2.1	0.008246	0.530134	0.027676	0.568994
2.2	0.155972	0.349764	0.155972	0.388624
2.3	0.192255	0.384689	0.192255	0.423549
2.4	0.203618	0.184188	0.203618	0.203618

2.5	0.000522	0.148427	0.000522	0.167857
2.6	0.011363	0.340682	0.011363	0.360112
2.7	0.011363	0.003817	0.011363	0.023248
2.8	0.011363	0.196491	0.011363	0.215921

AGGREGATING CORRECTIVE ACTION ROUTINE FOR TRADE 02

Compatibiility matrix for trade 02

Trade level aggregation level										
	0.0	1.1	1.3	2.1	2.2	2.3	2.4	2.6	2.7	2.8
0.0	1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1.1	-1	1	-1	0	0	1	0	0	0	1
1.3	-1	-1	1	1	1	0	0	0	0	0
2.1	-1	0	1	1	1	1	0	0	0	0
2.2	-1	0	1	1	1	0	0	1	0	0
2.3	-1	1	0	1	0	1	0	1	0	0
2.4	-1	0	0	0	0	0	1	0	0	0
2.6	-1	0	0	0	1	1	0	1	0	0
2.7	-1	0	0	0	0	0	0	0	1	1
2.8	-1	1	0	0	0	0	0	0	1	1

Trade 02 by Frequency of Occurrence					
Problem Source	DI	Freq. of Occ.	W	W*DI	Normalized W*DI
34	1	4	0.8	0.8	0.8
41	1	1	0.2	0.2	0.2
Sum =		5	1	1	1

	Original Data		Normalized Strengths	
ProbSour	34	41	34	41
0.0	0	0	0	0
1.1	0	1	0	0.333333

1.3	0	0.5	0	0.166667
2.1	0.5	0	0.106383	0
2.2	0.5	0	0.106383	0
2.3	0	1	0	0.333333
2.4	1	0.5	0.212766	0.166667
2.6	0.7	0	0.148936	0
2.7	1	0	0.212766	0
2.8	1	0	0.212766	0
Sum =	4.7	3	1	1
Compatibiliy matrix routine				
	1st Data	Coeff.		
0.0	0	-1		
1.1	0.066667	0.270213		
1.3	0.033333	0.136879		
2.1	0.085106	0.270213		
2.2	0.085106	0.322695		
2.3	0.066667	0.337589		
2.4	0.203546	0.203546		
2.6	0.119149	0.270922		
2.7	0.170213	0.340426		
2.8	0.170213	0.407092		

Aggregating corrective actions of Trade 02 by Manhours Lost

Trade 02 By Manhours Lost					
Problem Source	DI	Manhours Lost	W	W*DI	Normalized W*DI
34	1	13	0.8125	0.8125	0.8125
41	1	3	0.1875	0.1875	0.1875
Sum =		16	1	1	1
	Original Data		Normalized Strengths		
	34	41	34	41	
0.0	0	0	0	0	
1.1	0	1	0	0.333333	
1.3	0	0.5	0	0.166667	
2.1	0.5	0	0.106383	0	
2.2	0.5	0	0.106383	0	
2.3	0	1	0	0.333333	
2.4	1	0.5	0.212766	0.166667	
2.6	0.7	0	0.148936	0	
2.7	1	0	0.212766	0	
2.8	1	0	0.212766	0	
Sum =	4.7	3	1	1	

Compatibility Matrix Routine		
	1st Data	Coeff.
0.0	0	-1
1.1	0.0625	0.266622
1.3	0.03125	0.141622

2.1	0.086436	0.266622
2.2	0.086436	0.325133
2.3	0.0625	0.332447
2.4	0.204122	0.204122
2.6	0.121011	0.269947
2.7	0.172872	0.345745
2.8	0.172872	0.408245

Aggregating corrective actions routine for trade 02 using time lost criterion

Trade 02 by Time Lost					
Problem	DI	Time		W*DI	Normalized
Source		Lost	W		W*DI
34	1	1.3	0.764706	0.764706	0.764706
41	1	0.4	0.235294	0.235294	0.235294
Sum =		1.7	1	1	1
	Original Data		Normalized Strengths		
	34	41	34	41	
0.0	0	0	0	0	
1.1	0	1	0	0.333333	
1.3	0	0.5	0	0.166667	
2.1	0.5	0	0.106383	0	
2.2	0.5	0	0.106383	0	
2.3	0	1	0	0.333333	

2.4	1	0.5	0.212766	0.166667	
2.6	0.7	0	0.148936	0	
2.7	1	0	0.212766	0	
2.8	1	0	0.212766	0	
Sum =	4.7	3	1	1	

The adjusted corrective actions and their coefficients from the compatibility matrix routine are shown below:

Compatibility Matrix Routine		
	1st Data	Coeff.
0.0	0	-1
1.1	0.078431	0.28035
1.3	0.039216	0.123488
2.1	0.081352	0.28035
2.2	0.081352	0.315811
2.3	0.078431	0.352107
2.4	0.201919	0.201919
2.6	0.113892	0.273675
2.7	0.162703	0.325407
2.8	0.162703	0.403838

APPENDIX D PROJECT LEVEL ANALYSIS BY MANUAL CALCULATION

Project level analysis

Problem source - 41 Undermanning

System derived data:

Project dispersion index = 6/6 = 1.0
Site precipitation > 12
Project total time lost = 19.9
Project total manhours lost = 72.0
Manpower(percent_sufficient) = 3/20 = 15%
Project (percent_critical) = 3/6 * 100 = 50%
Project(percent_remain_duration) = (2/10 +3/9 + 3/9 + 7 + 8 + 9)/30 * 100% = 82.88%
Number of occurrence = 18
Total number of occurrence for all problem = 30
Site precipitation >= 12
problem(41, percent_critical, @perc) = 11/18*100% = 61.11%

Standard strength:

		V_{12}	V_{13}	V_{14}	
X	[	1.0	0.5	1.0	]

Project attributes:

		V_{12}	V_{13}	V_{14}	
Proj.	[	0.5	0.5	0.0	]

S(X, V):

		V_{12}	V_{13}	V_{14}	
X	[	0.5	0.25	0	]

T(V, Z):

		V_{12}	V_{13}	V_{14}	
2005	[	0.1	0	0	]
2003	[	1.0	0	0	]
1001	[	1.0	0	0	]
1003	[	0.4	0	0	]

R(X, Z):

		1.1	**1.3**	**2.3**	**2.5**	
X	**[**	**0.5**	**0.4**	**0.5**	**0.1**	**]**

AGGREGATION ROUTINE FOR PROJECT LEVEL

Weight distributions determine by frequency of occurrence are:

$W_{32} = 1/30 = 0.033$
$W_{34} = 6/30 = 0.200$
$W_{41} = 18/30 = 0.600$
$W_{46} = 1/30 = 0.033$
$W_{56} = 4/30 = 0.133$

Calculate Dispersion Index as:

$DI_{32} = 0.1667$
$DI_{34} = 0.5000$
$DI_{41} = 1.000$
$DI_{46} = 0.1667$
$DI_{56} = 0.3333$

Calculate modified weight as:

$W_{32} * DI_{32} = 0.0055$
$W_{34} * DI_{34} = 0.01$
$W_{41} * DI_{41} = 0.6$
$W_{46} * DI_{46} = 0.0055$
$W_{56} * DI_{56} = 0.0443$

0.6653

Renormalized modified weight, we have:

$W^*_{32} = 0.008267$
$W^*_{34} = 0.01503$
$W^*_{41} = 0.9018$
$W^*_{46} = 0.008267$
$W^*_{56} = 0.06659$

When multiply each of them with the corrective actions, we have:

$$Z = 0.008267 \times \begin{bmatrix} 0.0 \\ 1.0 \end{bmatrix} + 0.01503 \times \begin{bmatrix} 0.0 \\ 1.0 \end{bmatrix} +$$

$$0.9018 \times \begin{bmatrix} 1.1 & 1.3 & 2.3 & 2.5 \\ 0.333 & 0.267 & 0.333 & 0.0667 \end{bmatrix} +$$

$$0.008267 \times \begin{bmatrix} 0.0 \\ 1.0 \end{bmatrix} + 0.06659 \times \begin{bmatrix} 0.0 \\ 1.0 \end{bmatrix}$$

Project Level Compatibility Matrix for Manual Calculation Example					
	0.0	**1.1**	**1.3**	**2.3**	**2.5**
0.0	1	-1	-1	-1	-1
1.1	-1	1	1	1	0
1.3	-1	1	1	0	0
2.3	-1	1	0	1	1
2.5	-1	0	0	1	1
By Frequency of Occurrence					
		Freq. of			**Normalized**
	DI	**Occu.**	**W**	**DI*W**	**DI*W**
32	0.1667	1	0.033333	0.005557	0.007354
34	0.5	6	0.2	0.1	0.132353
41	1	18	0.6	0.6	0.79412
46	0.1667	1	0.033333	0.005557	0.007354
56	0.3333	4	0.133333	0.04444	0.058818
Sum =		30	1	0.755553	1

	Original		1st		
	Data	Coeff.	Run	Coeff.	
0.0	0.20588	-0.58871	0	-1	
1.1	0.264707	0.53575	0.470587	0.947043	
1.3	0.211765	0.270966	0.211765	0.682259	
2.3	0.264707	0.37688	0.264707	0.788172	
2.5	0.052941	0.112095	0.052941	0.317741	
By Manhours Lost					
Problem		Manhours			Normalized
Source	DI	Lost	W	DI*W	DI*W
32	0.1667	4	0.055556	0.009261	0.016132
34	0.5	18	0.25	0.125	0.217742
41	1	25	0.347222	0.347222	0.604839
46	0.1667	10	0.138889	0.023153	0.040331
56	0.3333	15	0.208333	0.069438	0.120956
Sum=		72	1	0.574074	1
	Original		1st		
	Data	Coeff.	Run	Coeff.	
0.0	0.395161	-0.20968	0	-1	
1.1	0.201613	0.169356	0.596774	0.959677	

1.3	0.16129	-0.03226	0.16129	0.758064	
2.3	0.201613	0.048388	0.201613	0.83871	
2.5	0.040323	-0.15323	0.040323	0.241936	
By Time Lost					
Problem		Time			Normalized
Source	DI	Lost	W	DI*W	DI*W
32	0.1667	1	0.050251	0.008377	0.009992
34	0.5	3.8	0.190955	0.095477	0.113886
41	1	14.5	0.728643	0.728643	0.869128
46	0.1667	0.5	0.025126	0.004188	0.004996
56	0.3333	0.1	0.005025	0.001675	0.001998
Sum=		19.9		0.838361	
	Original		1st		
	Data	Coeff.	Run	Coeff.	
0.0	0.130872	-0.73826	0	-1	
1.1	0.289709	0.680315	0.420581	0.942058	
1.3	0.231768	0.390606	0.231768	0.652349	
2.3	0.289709	0.506489	0.289709	0.768232	
2.5	0.057942	0.21678	0.057942	0.347651	

APPENDIX E SUPPORTIVE INFORMATION FOR CASE STUDY EXAMPLE

BENJAMIN YUE - EXTENDED EXAMPLE PROJECT

PRED/SUCC/PRODUCTION

File Used: D:\REP200\PROJ13\BENYUU

Select: All Activities
Sort: Activity Code

* Critical Activity
\+ Governing predecessor of an activity or successor governed by activity

Report Date: 19DEC93
Report Time: 14:28:52
Revision Number: 0
Progress Date: 18FEB94

ACTIVITY CODE	DESCRIPTION	PREDECESSORS ACT. CODE	DESCRIPTION	TYPE	PLOC	REL	LAG	OFF/LOC	SUCCESSORS ACT. CODE	DESCRIPTION	TYPE	SLOC	REL	LAG	OFF/LOC	LOC RANGE	PROD. DATA WORK	SKIP	DUR
090100	LAYOUT WALLS/INSTL STUD SILLS	+150100	ROUGH-IN S& W WATER RISERS	T		FS	0	0 N	+090200	INSTALL METAL STUDS	T		FS	0	0 N	MAIN- 2	1	0	3
																3- 10	1	0	2
090200	INSTALL METAL STUDS	+090100	LAYOUT WALLS/INSTL STUD SILLS	T		FS	0	0 N	* 090400	INSTALL EXTERNAL WALL BOARD	T		FS	0	0 N	MAIN- 10	1	0	3
									+G80200	INSTALL BLOCKING FOR WINDOWS	T		FS	0	0 N				
									+160100	ROUGH-IN ELECTRICAL	T		FS	0	0 N				
									+150200	ROUGH-IN COPPER PLUMBING	T		FS	0	0 N				
*090300	INSTALL INSULATION/VAPOUR BAR	* 090400	INSTALL EXTERNAL WALL BOARD	T		FS	0	0 N	*+090500	DRYWALL BOARDING	T		FS	0	0 N	MAIN- 10	1	0	3
		150200	ROUGH-IN COPPER PLUMBING	T		FS	0	0 N											
		160100	ROUGH-IN ELECTRICAL	T		FS	0	0 N											
		*+100100	INSTALL WINDOWS	T		FS	0	0 N											
*090400	INSTALL EXTERNAL WALL BOARD	*+120100	ERECT SCAFFOLDING FOR MASONRY	T		SS	1	1 N	*+100100	INSTALL WINDOWS	T		FF	2	0 N	MAIN- 2	1	0	3
		090200	INSTALL METAL STUDS	T		FS	0	0 N	*+100100	1NSTALL WINDOWS	T		SS	2	0 N	3- 10	1	0	3
									* 090300	INSTALL INSULATION/VAPOUR BAR	T		FS	0	0 N				
*090500	DRYWALL BOARDING	*+090300	INSTALL INSULATION/VAPOUR BAR	T		FS	0	0 N	*+090600	TAPE/FILL/SAND DRYWALL	T		FS	0	0 N	MAIN	1	0	4
		* 100100	INSTALL WINDOWS	T		FS	0	0 N								2- 10	1	0	5
*090600	TAPE/FILL/SAND DRYWALL	*+090500	DRYWALL BOARDING	T		FS	0	0 N								MAIN- 10	1	0	10
*100100	INSTALL WINDOWS	*+090400	INSTALL EXTERNAL WALL BOARD	T		SS	2	0 N	*+090300	INSTALL INSULATION/VAPOUR BAR	T		FS	0	0 N	MAIN	1	0	4
		*+090400	INSTALL EXTERNAL WALL BOARD	T		FF	2	0 N	+120200	BUILD BRICK WALLS	T		FS	0	0 N	2- 10	1	0	3
									* 090500	DRYWALL BOARDING	T		FS	0	0 N				
*120100	ERECT SCAFFOLDING FOR MASONRY	*+G80100	F/R/P/C/S SUPERSTRUCTURE	T		FS	0	5 N	*+090400	INSTALL EXTERNAL WALL BOARD	T		SS	1	1 N	MAIN	1	0	5
		* G80100	F/R/P/C/S SUPERSTRUCTURE	NT	5	FS	0	MAIN	120200	BUILD BRICK WALLS	T		FS	0	1 N	2- 10	1	0	3
		G80300	F/R/P/C/S HARD LANDSCAPING	NT	SITE	SS	5	MAIN											
120200	BUILD BRICK WALLS	* 120100	ERECT SCAFFOLDING FOR MASONRY	T		FS	0	1 N								MAIN	1	0	10
		*+100100	INSTALL WINDOWS	T		FS	0	0 N								2- 2	1	0	7
																3- 10	1	0	5
150100	ROUGH-IN S& W WATER RISERS	*+G80100	F/R/P/C/S SUPERSTRUCTURE	T		FS	0	2 N	+090100	LAYOUT WALLS/INSTL STUD SILLS	T		FS	0	0 N	MAIN- 10	1	0	3
150200	ROUGH-IN COPPER PLUMBING	+090200	INSTALL METAL STUDS	T		FS	0	0 N	* 090300	INSTALL INSULATION/VAPOUR BAR	T		FS	0	0 N	MAIN	1	0	3
																2- 10	1	0	4
160100	ROUGH-IN ELECTRICAL	+090200	INSTALL METAL STUDS	T		FS	0	0 N	* 090300	INSTALL INSULATION/VAPOUR BAR	T		FS	0	0 N	MAIN	1	0	5
																2- 2	1	0	7
																3- 10	1	0	5
*G80100	F/R/P/C/S SUPERSTRUCTURE	* G80400	START SUPERSTRUCTURE	MT	SITE	FS	0	MAIN	*+120100	ERECT SCAFFOLDING FOR MASONRY	T		FS	0	5 N	MAIN	1	0	12

ACTIVITY CODE	DESCRIPTION	PREDECESSORS ACT. CODE	DESCRIPTION	TYPE	PLOC	REL	LAG	OFF/LOC	SUCCESSORS ACT. CODE	DESCRIPTION	TYPE	SLOC	REL	LAG	OFF/LOC	LOC RANGE	PROD. DATA WORK	SKIP	DUR
									+150100	ROUGH-IN S& V WATER RISERS	T		FS	0	2 N	2- 2	1	0	8
									* 120100	ERECT SCAFFOLDING FOR MASONRY	MT	MAIN	FS	0	5	3- 5	1	0	6
									G00300	F/R/P/C/S HARD LANDSCAPING	MT	SITE	FS	0	5	6-ROOF	1	0	5
G00200	INSTALL BLOCKING FOR WINDOWS	+090200	INSTALL METAL STUDS	T		FS	0	0 N								MAIN	1	0	3
																2- 10	1	0	2
G00300	F/R/P/C/S HARD LANDSCAPING	* G00100	F/R/P/C/S SUPERSTRUCTURE	MT	5	FS	0	SITE	* 120100	ERECT SCAFFOLDING FOR MASONRY	MT	MAIN	SS	5	SITE	SITE	1	0	15
*G00400	START SUPERSTRUCTURE								* G00100	F/R/P/C/S SUPERSTRUCTURE	MT	MAIN	FS	0	SITE	SITE	1	0	M/A

FOR A TOTAL OF 16 ACTIVITIES

ACTIVITY ATTRIBUTES

File Used: D:\REP200\PROJ29\BENYUU

Select: All Activities
Sort: Activity Code

* Critical Activity
\+ Governing predecessor of an activity or successor governed by activity

Report Date: 20DEC93
Report Time: 14:06:25
Revision Number: 0
Progress Date: 04MAR94

ACTIVITY CODE	DESCRIPTION	High precipitation	Low precipitation	High temperature	Low temperature	Humidity	Wind	Ground conditions	Storage on site	Site congestion	Internal access	External access	Labour intensive	Equipment intensive	Buffer activity	Innovative methods	Design changes
090100	LAYOUT WALLS/INSTL STUD SILLS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	1.00	0.00	0.00	0.00	1.00

High inspection	Contract provision	Controlled environmen	Low tolerance	Learning curve effe	Design complexity
0.00	0.00	0.00	0.00	0.00	0.60

ACTIVITY CODE	DESCRIPTION	High precipitation	Low precipitation	High temperature	Low temperature	Humidity	Wind	Ground conditions	Storage on site	Site congestion	Internal access	External access	Labour intensive	Equipment intensive	Buffer activity	Innovative methods	Design changes
090200	INSTALL METAL STUDS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	1.00	0.00	0.00	0.00	1.00

High inspection	Contract provision	Controlled environmen	Low tolerance	Learning curve effe	Design complexity
0.00	0.00	0.00	0.00	0.00	0.40

ACTIVITY CODE	DESCRIPTION	High precipitation	Low precipitation	High temperature	Low temperature	Humidity	Wind	Ground conditions	Storage on site	Site congestion	Internal access	External access	Labour intensive	Equipment intensive	Buffer activity	Innovative methods	Design changes
*090300	INSTALL INSULATION/VAPOUR BAR	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.20

High inspection	Contract provision	Controlled environmen	Low tolerance	Learning curve effe	Design complexity
0.60	0.00	0.00	0.00	0.40	0.00

ACTIVITY CODE	DESCRIPTION	High precipitation	Low precipitation	High temperature	Low temperature	Humidity	Wind	Ground conditions	Storage on site	Site congestion	Internal access	External access	Labour intensive	Equipment intensive	Buffer activity	Innovative methods	Design changes
*090400	INSTALL EXTERNAL WALL BOARD	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.50

High inspection	Contract provision	Controlled environmen	Low tolerance	Learning curve effe	Design complexity
0.00	0.00	0.00	0.00	0.50	0.00

ACTIVITY CODE	DESCRIPTION	High precipitation	Low precipitation	High temperature	Low temperature	Humidity	Wind	Ground conditions	Storage on site	Site congestion	Internal access	External access	Labour intensive	Equipment intensive	Buffer activity	Innovative methods	Design changes
*090500	DRYWALL BOARDING	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	1.00	0.00	0.00	0.00	1.00

High inspection	Contract provision	Controlled environmen	Low tolerance	Learning curve effe	Design complexity
0.50	0.00	1.00	0.00	0.50	0.00

ACTIVITY CODE	DESCRIPTION	High precipitation	Low precipitation	High temperature	Low temperature	Humidity	Wind	Ground conditions	Storage on site	Site congestion	Internal access	External access	Labour intensive	Equipment intensive	Buffer activity	Innovative methods	Design changes
*090600	TAPE/FILL/SAND DRYWALL	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00

High inspection	Contract provision	Controlled environmen	Low tolerance	Learning curve effe	Design complexity
1.00	0.00	1.00	1.00	0.40	0.00

ACTIVITY CODE	DESCRIPTION	High precipitation	Low precipitation	High temperature	Low temperature	Humidity	Wind	Ground conditions	Storage on site	Site congestion	Internal access	External access	Labour intensive	Equipment intensive	Buffer activity	Innovative methods	Design changes
*100100	INSTALL WINDOWS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.40

High inspection	Contract provision	Controlled environmen	Low tolerance	Learning curve effe	Design complexity
0.50	0.00	0.00	0.00	0.50	0.00

ACTIVITY CODE	DESCRIPTION	High precipitation	Low precipitation	High temperature	Low temperature	Humidity	Wind	Ground conditions	Storage on site	Site congestion	Internal access	External access	Labour intensive	Equipment intensive	Buffer activity	Innovative methods	Design changes
*120100	ERECT SCAFFOLDING FOR MASONRY	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00

High inspection	Contract provision	Controlled environmen	Low tolerance	Learning curve effe	Design complexity
0.50	0.00	0.00	0.00	0.40	0.00

ACTIVITY CODE	DESCRIPTION	High precipitation	Low precipitation	High temperature	Low temperature	Humidity	Wind	Ground conditions	Storage on site	Site congestion	Internal access	External access	Labour intensive	Equipment intensive	Buffer activity	Innovative methods	Design changes
120200	BUILD BRICK WALLS	1.00	0.00	0.50	1.00	0.00	0.00	0.00	0.50	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00

High inspection	Contract provision	Controlled environmen	Low tolerance	Learning curve effe	Design complexity
0.60	0.00	0.50	0.50	0.50	1.00

ACTIVITY CODE	DESCRIPTION	High precipitation	Low precipitation	High temperature	Low temperature	Humidity	Wind	Ground conditions	Storage on site	Site congestion	Internal access	External access	Labour intensive	Equipment intensive	Buffer activity	Innovative methods	Design changes
150100	ROUGH-IN SA W WATER RISERS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.50	0.00	0.00	0.00	1.00

High inspection	Contract provision	Controlled environmen	Low tolerance	Learning curve effe	Design complexity
0.00	0.00	0.50	0.20	0.50	0.50

ACTIVITY CODE	DESCRIPTION	High precipitation	Low precipitation	High temperature	Low temperature	Humidity	Wind	Ground conditions	Storage on site	Site congestion	Internal access	External access	Labour intensive	Equipment intensive	Buffer activity	Innovative methods	Design changes
150200	ROUGH-IN COPPER PLUMBING	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.90	0.00	0.00	0.00	0.90

High inspection	Contract provision	Controlled environmen	Low tolerance	Learning curve effe	Design complexity
0.00	0.00	0.70	0.00	0.50	0.50

ACTIVITY CODE	DESCRIPTION	High precipitation	Low precipitation	High temperature	Low temperature	Humidity	Wind	Ground conditions	Storage on site	Site congestion	Internal access	External access	Labour intensive	Equipment intensive	Buffer activity	Innovative methods	Design changes
160100	ROUGH-IN ELECTRICAL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.90	0.00	0.00	0.00	0.90

High insp-ection	Contract -provision	Controlled environmen	Low toler-ance	Learning -curve effe	Design co-mplexity
0.00	0.00	0.70	0.00	0.50	0.60

ACTIVITY CODE	DESCRIPTION	High prec-ipitation	Low preci-pitation	High temp-erature	Low tempe-rature	Humidity	Wind	Ground co-nditions	Storage on site	Site cong-estion	Internal -access	External -access	Labour in-tensive	Equipment intensive	Buffer ac-tivity	Innovative methods	Design ch-anges
*G00100	F/R/P/C/S SUPERSTRUCTURE	1.00	0.00	0.60	1.00	0.00	0.00	0.00	1.00	0.00	0.00	1.00	0.90	0.00	0.00	0.00	1.00

High insp-ection	Contract -provision	Controlled environmen	Low toler-ance	Learning -curve effe	Design co-mplexity
1.00	1.00	0.00	0.70	0.90	1.00

ACTIVITY CODE	DESCRIPTION	High prec-ipitation	Low preci-pitation	High temp-erature	Low tempe-rature	Humidity	Wind	Ground co-nditions	Storage on site	Site cong-estion	Internal -access	External -access	Labour in-tensive	Equipment intensive	Buffer ac-tivity	Innovative methods	Design ch-anges
G00200	INSTALL BLOCKING FOR WINDOWS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	1.00	0.00	0.00

High insp-ection	Contract -provision	Controlled environmen	Low toler-ance	Learning -curve effe	Design co-mplexity
0.30	0.00	0.00	0.50	0.50	0.50

ACTIVITY CODE	DESCRIPTION	High prec-ipitation	Low preci-pitation	High temp-erature	Low tempe-rature	Humidity	Wind	Ground co-nditions	Storage on site	Site cong-estion	Internal -access	External -access	Labour in-tensive	Equipment intensive	Buffer ac-tivity	Innovative methods	Design ch-anges
G00300	F/R/P/C/S HARD LANDSCAPING	1.00	0.00	0.60	1.00	0.00	0.00	1.00	1.00	1.00	0.00	1.00	0.00	0.00	0.50	0.00	1.00

High insp-ection	Contract -provision	Controlled environmen	Low toler-ance	Learning -curve effe	Design co-mplexity
0.00	0.50	0.00	0.00	0.20	1.00

ACTIVITY CODE	DESCRIPTION	High prec-ipitation	Low preci-pitation	High temp-erature	Low tempe-rature	Humidity	Wind	Ground co-nditions	Storage on site	Site cong-estion	Internal -access	External -access	Labour in-tensive	Equipment intensive	Buffer ac-tivity	Innovative methods	Design ch-anges
*G00400	START SUPERSTRUCTURE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

High insp-ection	Contract -provision	Controlled environmen	Low toler-ance	Learning -curve effe	Design co-mplexity
0.00	0.00	0.00	0.00	0.00	0.00

FOR A TOTAL OF 16 ACTIVITIES

BENJAMIN YUE - EXTENDED EXAMPLE PROJECT

BATCH UPDATE
TRANSACTION REPORT

File Used: D:\REP200\PROJ13\BENYUU
Revision No: 0
Pre-Update Progress Date: -None-

Report Date: 18DEC93
Report Time: 18:25:52
New Progress Date: 31DEC93

ACTIVITY CODE	ACTIVITY LOC	ACTIVITY DESCRIPTION	PRE-UPDATE DATA ACTUAL/SCHED/EARLY START	PRE-UPDATE DATA FINISH	PRE-UPDATE DATA REM DUR	PRE-UPDATE DATA %S	PRE-UPDATE DATA %I	NEW DATA ACTUAL START	NEW DATA ACTUAL FINISH	NEW DATA REM DUR	NEW DATA %S	NEW DATA %I	STATUS OF ACTIVITY
G00100	MAIN	F/R/P/C/S SUPERSTRUCTURE	13DEC93	30DEC93	12			13DEC93	30DEC93	0		100	Start/Finish.
G00100	2	F/R/P/C/S SUPERSTRUCTURE	31DEC93	12JAN94	8			31DEC93	(12JAN94)	7		12	Start.
G00400	SITE	START SUPERSTRUCTURE	S13DEC93					13DEC93					Start/Finish.

BENJAMIN YUE - EXTENDED EXAMPLE PROJECT

BATCH UPDATE
TRANSACTION REPORT

File Used: D:\REP200\PROJ13\BENYUU
Revision No: 0
Pre-Update Progress Date: 31DEC93

Report Date: 18DEC93
Report Time: 18:27:28
New Progress Date: 04FEB94

ACTIVITY CODE	LOC	ACTIVITY DESCRIPTION	PRE-UPDATE DATA ACTUAL/SCHED/EARLY START	FINISH	REM DUR	%S	%I	NEW DATA ACTUAL START	FINISH	REM DUR	%S	%I	STATUS OF ACTIVITY
090100	MAIN	LAYOUT WALLS/INSTL STUD SILLS	26JAN94	28JAN94	3			26JAN94	28JAN94	0	100		Start/Finish.
	2	LAYOUT WALLS/INSTL STUD SILLS	03FEB94	07FEB94	3			03FEB94	(07FEB94)	1	66		Start.
090200	MAIN	INSTALL METAL STUDS	31JAN94	02FEB94	3			31JAN94	02FEB94	0	100		Start/Finish.
150100	MAIN	ROUGH-IN S& W WATER RISERS	21JAN94	25JAN94	3			21JAN94	25JAN94	0	100		Start/Finish.
	2	ROUGH-IN S& W WATER RISERS	31JAN94	02FEB94	3			31JAN94	02FEB94	0	100		Start/Finish.
150200	MAIN	ROUGH-IN COPPER PLUMBING	03FEB94	07FEB94	3			03FEB94	(07FEB94)	1	66		Start.
160100	MAIN	ROUGH-IN ELECTRICAL	03FEB94	09FEB94	5			03FEB94	(09FEB94)	3	40		Start.
G00100	2	F/R/P/C/S SUPERSTRUCTURE	A31DEC93	(12JAN94)	7		12	31DEC93	12JAN94	0	100		Finish.
G00100	3	F/R/P/C/S SUPERSTRUCTURE	13JAN94	28JAN94	6			13JAN94	28JAN94	0	100		Start/Finish.
G00100	4	F/R/P/C/S SUPERSTRUCTURE	21JAN94	28JAN94	6			21JAN94	28JAN94	0	100		Start/Finish.
G00100	5	F/R/P/C/S SUPERSTRUCTURE	31JAN94	07FEB94	6			31JAN94	(07FEB94)	1	83		Start.
G00200	MAIN	INSTALL BLOCKING FOR WINDOWS	03FEB94	07FEB94	3			03FEB94	(07FEB94)	1	66		Start.

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BENJAMIN YUE - EXTENDED EXAMPLE PROJECT

BATCH UPDATE
TRANSACTION REPORT

File Used: D:\REP200\PROJ13\BENYUU
Revision No: 0
Pre-Update Progress Date: 04FEB94

Report Date: 10DEC93
Report Time: 22:27:58
New Progress Date: 18FEB94

ACTIVITY CODE	LOC	ACTIVITY DESCRIPTION	PRE-UPDATE DATA ACTUAL/SCHED/EARLY START	FINISH	REM DUR	%S	%I	NEW DATA ACTUAL START	FINISH	REM DUR	%S	%I	STATUS OF ACTIVITY
090100	2	LAYOUT WALLS/INSTL STUD SILLS	A03FEB94	[07FEB94]	1		66	03FEB94	08FEB94	0		100	Finish.
	3	LAYOUT WALLS/INSTL STUD SILLS	11FEB94	14FEB94	2			11FEB94	15FEB94	0		100	Start/Finish.
	4	LAYOUT WALLS/INSTL STUD SILLS	18FEB94	21FEB94	2			18FEB94	[22FEB94]	2		50	Start.
090200	2	INSTALL METAL STUDS	08FEB94	10FEB94	3			09FEB94	14FEB94	0		100	Start/Finish.
	3	INSTALL METAL STUDS	15FEB94	17FEB94	3			15FEB94	18FEB94	0		100	Start/Finish.
120100	MAIN	ERECT SCAFFOLDING FOR MASONRY	15FEB94	21FEB94	5			18FEB94	[25FEB94]	5		20	Start.
150100	3	ROUGH-IN SA W WATER RISERS	08FEB94	10FEB94	3			08FEB94	11FEB94	0		100	Start/Finish.
	4	ROUGH-IN SA W WATER RISERS	15FEB94	17FEB94	3			15FEB94	18FEB94	0		100	Start/Finish.
150200	MAIN	ROUGH-IN COPPER PLUMBING	A03FEB94	[07FEB94]	1		66	03FEB94	07FEB94	0		100	Finish.
	2	ROUGH-IN COPPER PLUMBING	11FEB94	16FEB94	4			15FEB94	18FEB94	0		100	Start/Finish.
	3	ROUGH-IN COPPER PLUMBING	18FEB94	23FEB94	4								Postponed. No changes made.
160100	MAIN	ROUGH-IN ELECTRICAL	A03FEB94	[09FEB94]	3		40	03FEB94	10FEB94	0		100	Finish.
	2	ROUGH-IN ELECTRICAL	11FEB94	21FEB94	7			15FEB94	[23FEB94]	3		57	Start.
G80100	5	F/R/P/C/S SUPERSTRUCTURE	A31JAN94	[07FEB94]	1		83	31JAN94	09FEB94	0		100	Finish.
G80100	6	F/R/P/C/S SUPERSTRUCTURE	08FEB94	14FEB94	5			10FEB94	10FEB94	0		100	Start/Finish.
G80100	7	F/R/P/C/S SUPERSTRUCTURE	15FEB94	21FEB94	5								Postponed. No changes made.
G80200	MAIN	INSTALL BLOCKING FOR WINDOWS	A03FEB94	[07FEB94]	1		66	03FEB94	08FEB94	0		100	Finish.
G80200	2	INSTALL BLOCKING FOR WINDOWS	11FEB94	14FEB94	2			11FEB94	15FEB94	0		100	Start/Finish.
G80200	3	INSTALL BLOCKING FOR WINDOWS	18FEB94	21FEB94	2			18FEB94	[21FEB94]	1		50	Start.
G80300	SITE	F/R/P/C/S HARD LANDSCAPING	08FEB94	28FEB94	15			09FEB94	[04MAR94]	10		45	Start.

BENJAMIN YUE - EXTENDED EXAMPLE PROJECT

BATCH UPDATE
TRANSACTION REPORT

File Used: D:\REP288\PROJ13\BENYUU
Revision No: 8
Pre-Update Progress Date: 18FEB94

Report Date: 19DEC93
Report Time: 15:43:43
New Progress Date: 04MAR94

ACTIVITY CODE	LOC	ACTIVITY DESCRIPTION	PRE-UPDATE DATA ACTUAL/SCHED/EARLY START	FINISH	REM DUR	%S	%I	NEW DATA ACTUAL START	FINISH	REM DUR	%S	%I	STATUS OF ACTIVITY
090100	4	LAYOUT WALLS/INSTL STUD SILLS	A18FEB94	I22FEB94I	2		50	18FEB94	23FEB94	0		100	Finish.
	5	LAYOUT WALLS/INSTL STUD SILLS	03MAR94	04MAR94	2			03MAR94	04MAR94	0		100	Start/Finish.
090200	3	INSTALL METAL STUDS	A15FEB94	18FEB94	0		100	15FEB94	18FEB94	0		100	Finish.
	4	INSTALL METAL STUDS	23FEB94	25FEB94	3			23FEB94	01MAR94	0		100	Start/Finish.
090400	MAIN	INSTALL EXTERNAL WALL BOARD	01MAR94	03MAR94	3			02MAR94					No Finish/Remaining Duration. No changes made.
100100	MAIN	INSTALL WINDOWS	03MAR94	08MAR94	4								Postponed. No changes made.
120100	MAIN	ERECT SCAFFOLDING FOR MASONRY	A18FEB94	I25FEB94I	5		20	18FEB94	01MAR94	0		100	Finish.
	2	ERECT SCAFFOLDING FOR MASONRY	28FEB94	02MAR94	3			02MAR94					No Finish/Remaining Duration. No changes made.
150100	4	ROUGH-IN S& W WATER RISERS	A15FEB94	18FEB94	0		100	15FEB94	18FEB94	0		100	Finish.
	5	ROUGH-IN S& W WATER RISERS	28FEB94	02MAR94	3			28FEB94	03MAR94	0		100	Start/Finish.
150200	2	ROUGH-IN COPPER PLUMBING	A15FEB94	18FEB94	0		100	15FEB94	18FEB94	0		100	Finish.
	3	ROUGH-IN COPPER PLUMBING	21FEB94	24FEB94	4			21FEB94	25FEB94	0		100	Start/Finish.
	4	ROUGH-IN COPPER PLUMBING	28FEB94	03MAR94	4			28FEB94	04MAR94	0		100	Start/Finish.
160100	2	ROUGH-IN ELECTRICAL	A15FEB94	I23FEB94I	3		57	15FEB94	23FEB94	0		100	Finish.
	3	ROUGH-IN ELECTRICAL	24FEB94	02MAR94	5			24FEB94	04MAR94	0		100	Start/Finish.
	4	ROUGH-IN ELECTRICAL	03MAR94	09MAR94	5			04MAR94	I10MAR94I	4		20	Start.
G80100	6	F/R/P/C/S SUPERSTRUCTURE	A18FEB94	18FEB94	0		100	18FEB94	18FEB94	0		100	Finish.
G80100	7	F/R/P/C/S SUPERSTRUCTURE	21FEB94	25FEB94	5			21FEB94	28FEB94	0		100	Start/Finish.
G80100	8	F/R/P/C/S SUPERSTRUCTURE	28FEB94	04MAR94	5			01MAR94	I07MAR94I	1		90	Start.
G80200	3	INSTALL BLOCKING FOR WINDOWS	A18FEB94	I21FEB94I	1		50	18FEB94	23FEB94	0		100	Finish.
G80200	4	INSTALL BLOCKING FOR WINDOWS	28FEB94	01MAR94	2			28FEB94	02MAR94	0		100	Start/Finish.
G80300	SITE	F/R/P/C/S HARD LANDSCAPING	A09FEB94	I04MAR94I	18		45	09FEB94	I08MAR94I	2		85	Ongoing.

BENJAMIN YUE - EXTENDED EXAMPLE PROJECT

DAILY SITE WORK ENVIRONMENT REPORT

File Used: D:\REP288\PROJ29\BENYUU
Report Period: 07FEB94 to 04MAR94
Weather and Site Conditions.

x Non-worked Day

Report Date: 28DEC93
Report Time: 14:40:36
Progress Date: 04MAR94
Revision Number: 0

DATE	WEATHER CONDITIONS AM (a) Clear	Cloud	Rain	Snow	PM (b) Clear	Cloud	Rain	Snow	TEMP (c) High C	Low C	(d) Precip mm	(e) Wind Speed kph	SITE CONDITIONS GROUND CONDITIONS (f) Poor	Fair	Good	STORAGE ON SITE (g) Poor	Fair	Good	ACCESS TO SITE (h) Poor	Fair	Good	COMMENTS
07FEB94			X				X		1	-1	15	0		X			X			X		(d) Freezing rain onto formwork and steel.Couldn't proceed with pour.
08FEB94			X				X		2	-1	14	0		X			X			X		(d) More freezing rain. Site dangerous. Can't place slab.
09FEB94		X			X				4	1	0	0		X			X			X		
10FEB94		X					X		4	1	10	0		X			X			X		
11FEB94			X					X	1	-3	20	0			X		X			X		(d) Precipitation in form of freezing rain and snow.
14FEB94				X				X	1	-2	20	0			X		X			X		
15FEB94			X				X		7	2	15	0			X		X			X		(c) At last - some warmer weather.
16FEB94	X					X			5	2	0	0		X			X			X		(d) Snow and wet weather affecting morale.
17FEB94			X				X		4	1	15	0	X				X			X		
18FEB94			X				X		4	2	12	0	X				X			X		
21FEB94	X					X			4	1	0	0		X			X			X		
22FEB94			X				X		7	2	15	0	X				X			X		
23FEB94			X				X		6	1	16	0	X				X			X		
24FEB94		X			X				3	1	0	0	X				X			X		
25FEB94	X				X				-2	-5	0	0		X			X			X		
28FEB94	X				X				-3	-6	0	0		X			X			X		
01MAR94	X				X				1	-5	0	0		X			X			X		
02MAR94			X				X		5	-1	12	0	X				X			X		
03MAR94		X					X		6	2	10	0		X			X			X		
04MAR94	X					X			7	2	0	0		X			X			X		

BENJAMIN YUE - EXTENDED EXAMPLE PROJECT

DAILY SITE WORK FORCE REPORT

File Used: D:\REP288\PROJ9\BENYUU
Report Period: 07FEB94 - 04MAR94
All Responsibility Codes.

Report Date: 28DEC93
Report Time: 14:41:08
Progress Date: 04MAR94
Revision Number: 0

DATE	Resp Code	Trade	(i) Super-intendent #	(j) #	(k) Suf Y/N	TRADESMEN (l) Skill H	M	L	(m) Turnover H	M	L	(n) OverTime Hours	Comments
07FEB94	G	GENERAL CONTRACTOR	1	10	Y			X			X		
	09	DRYWALL	1	3	N		X				X		
	15	MECHANICAL		2	Y		X				X		
	16	ELECTRICAL		3	Y		X				X		
08FEB94	G	GENERAL CONTRACTOR	1	8	Y			X			X		
	09	DRYWALL		3	Y		X				X		
	15	MECHANICAL		3	Y		X				X		
	16	ELECTRICAL		3	Y		X				X		
09FEB94	G	GENERAL CONTRACTOR	1	10	Y		X				X		(l) Apprentices still exhibiting low skill levels. More instr. given
	09	DRYWALL		5	Y		X				X		
	15	MECHANICAL		3	Y		X				X		
	16	ELECTRICAL		3	Y		X				X		
10FEB94	G	GENERAL CONTRACTOR	1	9	N			X			X		
	09	DRYWALL		3	N		X				X		
	15	MECHANICAL		3	Y		X				X		
	16	ELECTRICAL		3	Y		X				X		
11FEB94	G	GENERAL CONTRACTOR	1	8	N			X			X		(j) Let half of the men go at noon because of snow.
	09	DRYWALL		4	Y			X			X		
	15	MECHANICAL		3	Y		X				X		
	16	ELECTRICAL		3	Y		X				X		
14FEB94	G	GENERAL CONTRACTOR	1	12	Y			X			X		
	09	DRYWALL		5	Y		X				X		
	15	MECHANICAL		3	Y		X				X		
	16	ELECTRICAL		3	Y		X				X		
15FEB94	G	GENERAL CONTRACTOR	1	12	Y		X				X		
	09	DRYWALL		4	Y			X			X		
	15	MECHANICAL		3	N		X				X		
	16	ELECTRICAL		3	Y		X				X		
16FEB94	G	GENERAL CONTRACTOR	1	12	Y		X				X		
	09	DRYWALL		4	N			X			X		
	15	MECHANICAL		4	Y		X				X		(j) Mech subtrade added extra man to push rough-in.
	16	ELECTRICAL		3	Y		X				X		
17FEB94	G	GENERAL CONTRACTOR	1	9	N			X			X		
	09	DRYWALL		4	N			X			X		
	15	MECHANICAL		4	Y		X				X		
	16	ELECTRICAL		3	Y		X				X		
18FEB94	G	GENERAL CONTRACTOR	1	9	N			X			X		

DATE	Resp Code	Trade	(i) Super-intendent #	(j) #	(k) Suf Y/N	TRADESMEN (l) Skill H	(l) Skill M	(l) Skill L	(m) Turnover H	(m) Turnover M	(m) Turnover L	(n) OverTime Hours	Comments
	09	DRYWALL		6	Y			X			X		
	12	MASONRY		4	Y		X				X		
	15	MECHANICAL		2	N		X				X		
	16	ELECTRICAL		3	Y		X				X		
21FEB94	G	GENERAL CONTRACTOR	1	9	N			X			X		
	09	DRYWALL		4	N		X				X		
	12	MASONRY		5	Y		X				X		
	15	MECHANICAL		2	N		X				X		
	16	ELECTRICAL		3	Y		X				X		
22FEB94	G	GENERAL CONTRACTOR	1	8	N			X			X		
	09	DRYWALL		1	N		X				X		
	12	MASONRY		5	Y		X				X		
	15	MECHANICAL		2	N		X				X		
	16	ELECTRICAL		3	Y		X				X		
23FEB94	G	GENERAL CONTRACTOR	1	9	N			X			X		
	09	DRYWALL		2	N		X				X		
	12	MASONRY		5	Y		X				X		
	15	MECHANICAL		3	Y		X				X		
	16	ELECTRICAL		3	Y		X				X		
24FEB94	G	GENERAL CONTRACTOR	1	11	Y		X				X		
	09	DRYWALL		3	Y			X			X		
	12	MASONRY		5	Y		X				X		
	15	MECHANICAL		3	Y		X				X		
	16	ELECTRICAL		3	Y		X				X		
25FEB94	G	GENERAL CONTRACTOR	1	9	N			X			X		
	09	DRYWALL		3	Y			X			X		
	12	MASONRY		5	Y		X				X		
	15	MECHANICAL		3	Y		X				X		
	16	ELECTRICAL		2	N		X				X		
28FEB94	G	GENERAL CONTRACTOR	1	11	Y		X				X		
	09	DRYWALL		2	N			X			X		
	12	MASONRY		5	Y		X				X		
	15	MECHANICAL		1	N		X				X		
	16	ELECTRICAL			N		X				X		
01MAR94	G	GENERAL CONTRACTOR	1	9	N			X			X		
	09	DRYWALL		1	N		X				X		
	12	MASONRY		5	Y		X				X		
	15	MECHANICAL		1	N		X				X		
	16	ELECTRICAL			N		X				X		
02MAR94	G	GENERAL CONTRACTOR	1	9	N			X			X		
	09	DRYWALL		4	Y		X				X		
	12	MASONRY		4	Y		X				X		
	15	MECHANICAL		3	Y		X				X		
	16	ELECTRICAL		2	N		X				X		
03MAR94	G	GENERAL CONTRACTOR	1	9	N		X				X		
	09	DRYWALL		4	Y		X				X		
	12	MASONRY		4	Y		X				X		
	15	MECHANICAL		3	Y		X				X		

DATE	Resp Code	Trade	(i) Super-intendent #	(j) #	(k) Suf Y/N	TRADESMEN (l) Skill H	M	L	(m) Turnover H	M	L	(n) OverTime Hours	Comments
	16	ELECTRICAL		3	Y		X				X		
04MAR94	G	GENERAL CONTRACTOR	1	11	Y		X				X		
	09	DRYWALL		4	Y		X				X		
	12	MASONRY		3	Y		X				X		
	15	MECHANICAL		3	Y		X				X		
	16	ELECTRICAL		3	Y		X				X		

BENJAMIN YUE - EXTENDED EXAMPLE PROJECT

DAILY SITE PROBLEM SOURCES REPORT

File Used: D:\REP200\PROJ29\BENYUU
Report Period: 07FEB94 - 04MAR94
All Problem Codes for All Activities.

* Critical	E Extra Work Order
x Non-worked Day	L Letter
! Unscheduled	M Memo
B Backcharge	T Telephone

Report Date: 28DEC93
Report Time: 14:37:06
Progress Date: 04MAR94
Revision Number: 0

DATE	ACTIVITY/EXTRA WORK ORDER/BACK CHARGE CODE	LOC	RESP	DESCRIPTION	PROBLEM DESCRIPTION	PROBLEM RESPONSIBILITY CODE	NAME	ACTION CODES	MAN HOURS LOST F_EST	ADJ	TOTAL	DAYS LOST F_EST	ADJ	TOTAL
PROBLEM: (11) Too much precipitation														
07FEB94	C00100	5	G	F/R/P/C/S SUPERSTRUCTURE	Freezing rain delayed concrete pour.				40.00	40.00		1.00	1.00	
08FEB94	! C00100	5	G	F/R/P/C/S SUPERSTRUCTURE	Freezing rain again. Let workers on superstructure go at 8:30 am.				30.00	30.00		1.00	1.00	
	C00300	SITE	G	F/R/P/C/S HARD LANDSCAPING	Freezing rain led to postponement of start of hard landscaping. Since it is critical, this will delay the job.							1.00	1.00	
11FEB94	C00100	6	G	F/R/P/C/S SUPERSTRUCTURE	Freezing rain and snow making working conditions impossible. Let men go at noon.				6.00	6.00		0.50	0.50	
	C00300	SITE	G	F/R/P/C/S HARD LANDSCAPING	Freezing rain and snow making layout work and preliminary work very difficult. Let work crew in afternoon.				4.00	4.00		0.50	0.50	
14FEB94	C00100	6	G	F/R/P/C/S SUPERSTRUCTURE	Heavy snow making work very slow. Shoveled off slab formwork. Kept having to clean because of snow.				6.00	6.00		0.50	0.50	
	C00300	SITE	G	F/R/P/C/S HARD LANDSCAPING	Snow slowing work on hard landscaping. This will affect start of scaffolding erection, and delay completion of project. Suggest we notify architect and request extension.			M Request time ext r	3.00	3.00		0.50	0.50	
15FEB94	! C00100	6	G	F/R/P/C/S SUPERSTRUCTURE	Heavy rain resulting in lower productivity and reduced morale. Divided estimate of mhrs lost between each problem source.				4.00	4.00				
	C00300	SITE	G	F/R/P/C/S HARD LANDSCAPING	Heavy rain slowing productivity.				4.00	4.00				
17FEB94	! C00100	6	G	F/R/P/C/S SUPERSTRUCTURE	Had to postponed pour. Thought we could catch it at mid day.							1.00	1.00	
	C00300	SITE	G	F/R/P/C/S HARD LANDSCAPING	Heavy rain slowing production. Try and get extension.				6.00	6.00		0.50	0.50	
18FEB94	! C00100	6	G	F/R/P/C/S SUPERSTRUCTURE	Went ahead with the pour. Will have to do some grinding of the slab later because of rain damage to the finish.				8.00	8.00				
22FEB94	C00100	7	G	F/R/P/C/S SUPERSTRUCTURE	Heavy rain affecting productivity.				6.00	6.00				
23FEB94	C00100	7	G	F/R/P/C/S SUPERSTRUCTURE	Rain affecting productivity.				6.00	6.00				
02MAR94	C00100	8	G	F/R/P/C/S SUPERSTRUCTURE	Rain, especially freezing rain, slowing work.				4.00	4.00		0.25	0.25	
								SUBTOTALS	127.00	127.00		6.75	6.75	
PROBLEM: (31) Insuff./Incompl. Drawing														
07FEB94	160100	MAIN	16	ROUGH-IN ELECTRICAL	Drawings for electrical work are incomplete. Not sure where to place all boxes for outlets, ceiling fixtures, etc.				4.00	4.00		0.50	0.50	
08FEB94	160100	MAIN	16	ROUGH-IN ELECTRICAL	Work really being slowed because electrical drawings not coordinated with architectural drawings. Will lose at least another half day. Electrical sub complaining about loss in productivity.				6.00	6.00		0.50	0.50	
09FEB94	C00300	SITE	G	F/R/P/C/S HARD LANDSCAPING	Drawings for hard landscaping incomplete and misleading. Will proceed with layout, and get architect to check.				4.00	4.00		0.50	0.50	
10FEB94	C00300	SITE	G	F/R/P/C/S HARD LANDSCAPING	Incomplete drawings led to layout error. Time counted against code 57 Send note to architect requesting time extension because this activity is critical.			M Request time exten						
11FEB94	C00300	SITE	G	F/R/P/C/S HARD LANDSCAPING	Poor quality of drawings still causing problems in layout. Not able to get clear answers from architect.			M To arch. Drawings	3.00	3.00		0.25	0.25	
15FEB94	160100	2	16	ROUGH-IN ELECTRICAL	Drawings still not complete enough. Since this is first floor of typical layout, drawing fixes for previous floor not applicable. Will rough-in what is known - get clarification from architect.			M Seek clarif. re el				0.50	0.50	

DATE	ACTIVITY/EXTRA WORK ORDER/BACK CHARGE CODE	LOC	RESP	DESCRIPTION	PROBLEM DESCRIPTION	PROBLEM RESPONSIBILITY CODE	NAME	ACTION CODES	MAN HOURS LOST F_EST	ADJ	TOTAL	DAYS LOST F_EST	ADJ	TOTAL
								SUBTOTALS	17.00		17.00	2.25		2.25
PROBLEM: (32) Drawing errors														
07FEB94	090100	2		09 LAYOUT WALLS/INSTL STUD SILL	Loosing time because drawing errors resulting in layout errors.				6.00		6.00	1.00		1.00
15FEB94	G00300	SITE		G F/R/P/C/S HARD LANDSCAPING	Error discovered in drawings - architectural, structural & electrical not coordinated. Had to change some of the formwork.				4.00		4.00	0.25		0.25
								SUBTOTALS	10.00		10.00	1.25		1.25
PROBLEM: (34) Conflicting information														
16FEB94	160100	2		16 ROUGH-IN ELECTRICAL	Some conflicts in instructions re placement of electrical rough-in and plumbing rough-in. Will lose approx. 1/4 day in resolving conflicts.							0.25		0.25
17FEB94	! 150200	2		15 ROUGH-IN COPPER PLUMBING	Still experiencing some lost time from conflicts in design drawings.							0.25		0.25
21FEB94	G00300	SITE		G F/R/P/C/S HARD LANDSCAPING	Structural, electrical and landscape drawings inconsistent. Lost time and manhours trying to resolve conflicts.				4.00		4.00	0.25		0.25
23FEB94	G00300	SITE		G F/R/P/C/S HARD LANDSCAPING	Conflicting information in drawings has resulted in mistake in formwork. Had to tear part of it out and rebuild. Loss of both manhours and time.				8.00		8.00	0.50		0.50
28FEB94	G00300	SITE		G F/R/P/C/S HARD LANDSCAPING	More conflicts discovered in drawings - this time deals with blockouts for mechanical and electrical. Talk with architect. Start thinking about a claim.			E Open EWO re landsc	4.00		4.00	0.25		0.25
01MAR94	G00300	SITE		G F/R/P/C/S HARD LANDSCAPING	Conflicting information slowing production. Waiting for information. Running out of work for even reduced manpower level because of lack of clarifications.				4.00		4.00	0.50		0.50
02MAR94	090400	MAIN		09 INSTALL EXTERNAL WALL BOARD	Need some clarifications on boarding around windows. Don't know all details of how windows to be fastened.							0.25		0.25
	G00300	SITE		G F/R/P/C/S HARD LANDSCAPING	Conflicting information leading to more productivity loss and errors.				6.00		6.00	0.25		0.25
03MAR94	090400	MAIN		09 INSTALL EXTERNAL WALL BOARD	Still waiting for details around windows.							0.25		0.25
	100100	MAIN		10 INSTALL WINDOWS	Can't start installing windows until details of external boarding around windows sorted out.							1.00		1.00
								SUBTOTALS	26.00		26.00	3.75		3.75
PROBLEM: (41) Insufficient manpower														
10FEB94	090200	2		09 INSTALL METAL STUDS	Seems that drywall subtrade light on manpower. Check numbers with him.							0.25		0.25
11FEB94	! 090200	2		09 INSTALL METAL STUDS	Drywaller undermanning job. As well, skill level of studders not up to par. Recorded problem against skill level as well.							0.25		0.25
15FEB94	150200	2		15 ROUGH-IN COPPER PLUMBING	Not enough men to get copper rough-in moving quickly. May lose 0.5 to 1 days.							0.50		0.50
17FEB94	! G00100	6		G F/R/P/C/S SUPERSTRUCTURE	Insufficient manpower affecting pace of work. Reallocated personnel from hard landscaping, but they have to get familiarized with the routine.				6.00		6.00	0.20		0.20
	G00300	SITE		G F/R/P/C/S HARD LANDSCAPING	Most of the manpower has been reassigned to superstructure work because not enough men showed up today.							0.50		0.50
18FEB94	! 150200	2		15 ROUGH-IN COPPER PLUMBING	Not enough men showed today. They were supposed to be finished by noon then move on to next floor. Instead, it took all day.	15	MECHANICAL					0.50		0.50
	150200	3		15 ROUGH-IN COPPER PLUMBING	Start postponed until tomorrow because of insufficient manpower. Lost time already counted for previous location.	15	MECHANICAL							
	G00200	3		G INSTALL BLOCKING FOR WINDOWS	Only one man working because short of manpower due to weather.							0.50		0.50
21FEB94	090100	4		09 LAYOUT WALLS/INSTL STUD SILL	Light on manpower. May affect duration. Check manpower level tomorrow.	09	DRYWALL							
	150200	3		15 ROUGH-IN COPPER PLUMBING	Seem to be sending men to another job. Going to stretch out duration. Since not critical, probably ok. Keep an eye on it.	15	MECHANICAL					0.50		0.50
	G00100	7		G F/R/P/C/S SUPERSTRUCTURE	Working with undersized crew. Grabbed manpower from landscaping.							0.20		0.20

DATE	ACTIVITY/EXTRA WORK ORDER/BACK CHARGE CODE	LOC	RESP	DESCRIPTION	PROBLEM DESCRIPTION	PROBLEM RESPONSIBILITY CODE	NAME	ACTION CODES	MAN HOURS LOST F_EST	ADJ	TOTAL	DAYS LOST F_EST	ADJ	TOTAL
	G00200	3	G	INSTALL BLOCKING FOR WINDOWS	Not enough men on site today. Reallocated one person from blocking to superstructure. Will extend blocking work duration.							0.50		0.50
22FEB94	090100	4	09	LAYOUT WALLS/INSTL STUD SILL	Lack of manpower slowing production.							0.25		0.25
	150200	3	15	ROUGH-IN COPPER PLUMBING	Lack of manpwer impeding production.							0.33		0.33
	G00100	7	G	F/R/P/C/S SUPERSTRUCTURE	Short on manpower. Slowing down production. Complicated by rain.	15	MECHANICAL					0.50		0.50
!	G00200	3	G	INSTALL BLOCKING FOR WINDOWS	Because of shortage of manpower, assigned all men to superstructure. Will lose a day on blocking. Not critical - ok.							1.00		1.00
	G00300	SITE	G	F/R/P/C/S HARD LANDSCAPING	Assigned all men to superstructure because of manpower shortage. Will lose day. Critical phase of landscaping almost over because not interfering with scaffolding erection.							1.00		1.00
23FEB94	090200	4	09	INSTALL METAL STUDS	Lack of manpower slowing production.									
	150200	3	15	ROUGH-IN COPPER PLUMBING	Light on manpower.									
	G00300	SITE	G	F/R/P/C/S HARD LANDSCAPING	Working with only a partial crew because of shortage of manpower. Superstructure is top priority.							0.25		0.25
25FEB94	090200	4	09	INSTALL METAL STUDS	Light on manpower, and quality still poor. Won't finish activity until Monday.							0.25		0.25
	160100	3	16	ROUGH-IN ELECTRICAL	Fewer men today. May slow down work on electrical.							0.25		0.25
	G00100	7	G	F/R/P/C/S SUPERSTRUCTURE	Working with undersized crew.							0.10		0.10
28FEB94	! 090200	4	09	INSTALL METAL STUDS	Not enough manpower to get activity finished. Lost another day.							1.00		1.00
	150200	4	15	ROUGH-IN COPPER PLUMBING	Not enough manpower to really get going. Will lose a day.							1.00		1.00
	160100	3	16	ROUGH-IN ELECTRICAL	Nobody showed up.							1.00		1.00
01MAR94	090400	MAIN	09	INSTALL EXTERNAL WALL BOARD	Postponed start because of lack of manpower.	16	ELECTRICAL					1.00		1.00
	150100	5	15	ROUGH-IN S& W WATER RISERS	Work proceeding slowly because of lack of manpower due to cold weather?	09	DRYWALL					1.00		1.00
						15	MECHANICAL					0.50		0.50
	150200	4	15	ROUGH-IN COPPER PLUMBING	Lack of manpower meant no work done on this.	15	MECHANICAL					1.00		1.00
	160100	3	16	ROUGH-IN ELECTRICAL	Nobody showed because of cold weather?	16	ELECTRICAL					1.00		1.00
	G00100	8	G	F/R/P/C/S SUPERSTRUCTURE	Light on manpower. Seems that tradesmen not showing up because of cold weather. Putting most of manpower on superstructure.							0.25		0.25
	G00200	4	G	INSTALL BLOCKING FOR WINDOWS	Allocated manpower to superstructure.							1.00		1.00
02MAR94	G00300	SITE	G	F/R/P/C/S HARD LANDSCAPING	Poor weather causing some workers to stay away. Working with undersized crew.							0.50		0.50
03MAR94	G00300	SITE	G	F/R/P/C/S HARD LANDSCAPING	Working with only a partial crew because weather causing some workers not to show up.							0.50		0.50
								SUBTOTALS	6.00		6.00	16.50		16.50
PROBLEM: (44) Low skill level														
07FEB94	G00200	MAIN	G	INSTALL BLOCKING FOR WINDOWS	Using apprentice carpenters. Their skill level is mismatched to the task. Loosing productivity and time.				4.00		4.00	0.50		0.50
08FEB94	! G00200	MAIN	G	INSTALL BLOCKING FOR WINDOWS	Low skill level of apprentices slowing pace of production on blocking.				4.00		4.00	0.50		0.50
11FEB94	! 090200	2	09	INSTALL METAL STUDS	Told drywaller to weed out his work crew. Low skill level leading to damage to metal studs; some not plumb. Time counted against manpower level.									
	G00100	6	G	F/R/P/C/S SUPERSTRUCTURE	Low skill level leading to problems in construction. Time lost recorded under errors in construction.									
	G00200	2	G	INSTALL BLOCKING FOR WINDOWS	Apprentices still need a lot of guidance in doing blocking work. Have wood grain running wrong way. Not fastening blocking securely enough.				4.00		4.00	0.50		0.50
14FEB94	! 090200	2	09	INSTALL METAL STUDS	Low skill level of studders will cause quality problems later.									
	G00200	2	G	INSTALL BLOCKING FOR WINDOWS	We are losing money on these apprentices. Suggest we let one go and replace with more seasoned carpenter who can oversee work of apprentice.				4.00		4.00	0.50		0.50
15FEB94	090200	3	09	INSTALL METAL STUDS	Low skill level of studders leading to too many mistakes. Have to go back and replumb some of the studs. Also, details for drop ceilings in bathrooms not being adhered to.							0.50		0.50
16FEB94	090200	3	09	INSTALL METAL STUDS	Big confrontation over crappy work being done by studders. They were told that we will back charge for replumbing studs. Also, some studs are bent and have to be replaced. See rework code.									

DATE	ACTIVITY/EXTRA WORK ORDER/BACK CHARGE CODE	LOC	RESP	DESCRIPTION	PROBLEM DESCRIPTION	PROBLEM RESPONSIBILITY CODE	NAME	ACTION CODES	MAN HOURS LOST F_EST	ADJ	TOTAL	DAYS LOST F_EST	ADJ	TOTAL
17FEB94	090200	3	09	INSTALL METAL STUDS	Sloppy work still being performed. Stated that will backcharge again.							0.25		0.25
	! G00100	6	G	F/R/P/C/S SUPERSTRUCTURE	Low skill level impacting on productivity.									
18FEB94	! 090200	3	09	INSTALL METAL STUDS	Skill level not much improved, although saw some new faces in the crew.	09	DRYWALL		4.00		4.00			
								SUBTOTALS	20.00		20.00	2.75		2.75
PROBLEM: (46) Low motivation/morale														
15FEB94	! G00100	6	G	F/R/P/C/S SUPERSTRUCTURE	Low morale due to lousy weather - impacting negatively on productivity				4.00		4.00			
18FEB94	G00300	SITE	G	F/R/P/C/S HARD LANDSCAPING	Guys are somewhat demoralized because of continued rain. Affecting productivity.				4.00		4.00			
04MAR94	G00300	SITE	G	F/R/P/C/S HARD LANDSCAPING	Workers getting fed up because of lack of information and conflicts in instructions given.				4.00		4.00	0.50		0.50
								SUBTOTALS	12.00		12.00	0.50		0.50
PROBLEM: (52) Rework (Workmanship)														
16FEB94	090200	3	09	INSTALL METAL STUDS	Correction of poor quality work will cost a day.							1.00		1.00
								SUBTOTALS				1.00		1.00
PROBLEM: (56) Error in construction														
10FEB94	G00100	6	G	F/R/P/C/S SUPERSTRUCTURE	Error in formwork construction results from low skill level.				6.00		6.00	0.25		0.25
11FEB94	G00100	6	G	F/R/P/C/S SUPERSTRUCTURE	Errors being made in layout of steel and using correct bars. Attribute in part to low skill levels. Need to spend more time checking.				6.00		6.00	0.10		0.10
	G00300	SITE	G	F/R/P/C/S HARD LANDSCAPING	Low skill levels compounding problems of poorly coordinated drawings, leading to compounding effect of errors.				3.00		3.00			
14FEB94	G00100	6	G	F/R/P/C/S SUPERSTRUCTURE	Picked up more errors in reinforcing steel layout due too low skill levels.				2.00		2.00			
18FEB94	G00300	SITE	G	F/R/P/C/S HARD LANDSCAPING	Lack of manpower, low skill level and conflicting drawings leading to construction errors. Had to modify forms.				3.00		3.00	0.25		0.25
21FEB94	G00200	3	G	INSTALL BLOCKING FOR WINDOWS	Poor skill level leading to installation problems. Blocking not being properly fastened.							0.20		0.20
	G00300	SITE	G	F/R/P/C/S HARD LANDSCAPING	Conflicting information and low skill levels leading to errors. Affecting productivity and duration.				2.00		2.00	0.10		0.10
22FEB94	G00100	7	G	F/R/P/C/S SUPERSTRUCTURE	Error in layout of steel again. The guys can't read drawings. Have to take more time providing instructions and checking work.				5.00		5.00	0.20		0.20
23FEB94	G00100	7	G	F/R/P/C/S SUPERSTRUCTURE	More errors in steel layout and in buttoning up forms.				2.50		2.50	0.10		0.10
	G00300	SITE	G	F/R/P/C/S HARD LANDSCAPING	Made a mistake in layout of part of the forms because of conflicting information in drawings. Time lost charge against conflicting information code.									
24FEB94	090200	4	09	INSTALL METAL STUDS	Now have enough men, but poor quality of work force leading to errors in stud walls. Out of plumb, some members damaged, details in bathroom not being built properly. Will affect boarding later.							0.25		0.25
25FEB94	090200	4	09	INSTALL METAL STUDS	Poor quality of work force and lack of effective supervision resulting in errors. Super having to spend to much time checking work. Tell drywall sub that will start backcharging for superivision.							0.25		0.25
	G00300	SITE	G	F/R/P/C/S HARD LANDSCAPING	Low skill levels and poor drawings leading to more construction errors.				2.00		2.00	0.20		0.20
01MAR94	G00300	SITE	G	F/R/P/C/S HARD LANDSCAPING	Low skill levels causing more problems again.				2.00		2.00			
02MAR94	G00300	SITE	G	F/R/P/C/S HARD LANDSCAPING	More errors coming up because of conflicting information in drawings. Talked to architect - told her it is top priority to resolve differences in drawings. See conflicting info code for time estimates									
04MAR94	G00300	SITE	G	F/R/P/C/S HARD LANDSCAPING	Another error, due to conflicts. Morale of staff being affected. Architect claims that it is our error.				8.00		8.00	0.50		0.50

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								SUBTOTALS	41.50		41.50	2.40		2.40
PROBLEM: (57) Layout error														
07FEB94	090100	2	09	LAYOUT WALLS/INSTL STUD SILL	Layout error caused by poor quality of drawings and error in drawings. Subtrade wants to bill for time and manhours lost. Time counted under drawing error code.									
08FEB94	! 090100	2	09	LAYOUT WALLS/INSTL STUD SILL	Layout error because of drawing error slowed pace of work. Finally completed today. Time lost estimated yesterday,									
	150100	3	15	ROUGH-IN S& V WATER RISERS	Mechanical subtrade put sleeving in wrong place when floor slab built. Will require coring of slab. Will lose a day or two. This problem will exist on next slab as well. Change layout for remaining slabs.	15	MECHANICAL					1.00		1.00
09FEB94	150100	3	15	ROUGH-IN S& V WATER RISERS	Layout error for sleeving for risers more than at first thought. More drilling will be required. Will lose at least another day.							1.00		1.00
10FEB94	150100	3	15	ROUGH-IN S& V WATER RISERS	Hitting reinforcing steel when drilling. Slowing drilling down. Will probably lose another day.							1.00		1.00
	G00300	SITE	G	F/R/P/C/S HARD LANDSCAPING	Discovered a layout error in positioning retaining and planter walls on main slab. Attribute to poor drawings, including inconsistencies.				6.00		6.00	1.00		1.00
11FEB94	090100	3	09	LAYOUT WALLS/INSTL STUD SILL	Found drywall subtrade not using updated drawings. Resulted in minor layout error.							0.25		0.25
14FEB94	090100	3	09	LAYOUT WALLS/INSTL STUD SILL	Layout error cost us an extra half day.							0.50		0.50
15FEB94	150100	4	15	ROUGH-IN S& V WATER RISERS	Layout error will add extra day because of requirement to drill slab for new location of risers.							1.00		1.00
								SUBTOTALS	6.00		6.00	5.75		5.75
PROBLEM: (72) Poor ground conditions														
18FEB94	120100	MAIN	12	ERECT SCAFFOLDING FOR MASONR	Poor ground conditions caused by continued rains means extra care required in setting up scaffolding.							0.25		0.25
22FEB94	120100	MAIN	12	ERECT SCAFFOLDING FOR MASONR	Poor ground conditions because of rain making set-up difficult.							0.25		0.25
23FEB94	120100	MAIN	12	ERECT SCAFFOLDING FOR MASONR	Poor ground conditions because of rain slowing scaffolding set-up.							0.25		0.25
								SUBTOTALS				0.75		0.75
PROBLEM: (95) Delay in award. contract														
15FEB94	120100	MAIN	12	ERECT SCAFFOLDING FOR MASONR	Sub just phoned. Says that because we were slow in awarding contract, that he is having a hard time in securing enough scaffolding. May need an extra day or two. Can't count today because pred. not done.									
16FEB94	120100	MAIN	12	ERECT SCAFFOLDING FOR MASONR	Subtrade having difficult time in rounding up enough scaffolding. Will lose another day. Could have started to set up, because pred. almost far enough along.							1.00		1.00
17FEB94	120100	MAIN	12	ERECT SCAFFOLDING FOR MASONR	Subtrade will have to bring scaffolding in from out of town. Blaming late award of contract.							1.00		1.00
21FEB94	120100	MAIN	12	ERECT SCAFFOLDING FOR MASONR	Still having problems getting enough scaffolding. May delay activity some more. Best estimate now is another day.							1.00		1.00
25FEB94	120100	MAIN	12	ERECT SCAFFOLDING FOR MASONR	Trade complaining more about shortage of scaffolding and blaming us for late award. May affect pace of work on upper levels.									
03MAR94	! 120100	2	12	ERECT SCAFFOLDING FOR MASONR	Running out of scaffolding. Will take an extra day to complete second floor.							1.00		1.00
								SUBTOTALS				4.00		4.00
								TOTALS	265.50		265.50	47.73		47.73

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BENJAMIN YUE - EXTENDED EXAMPLE PROJECT

BASELINE SCHEDULE

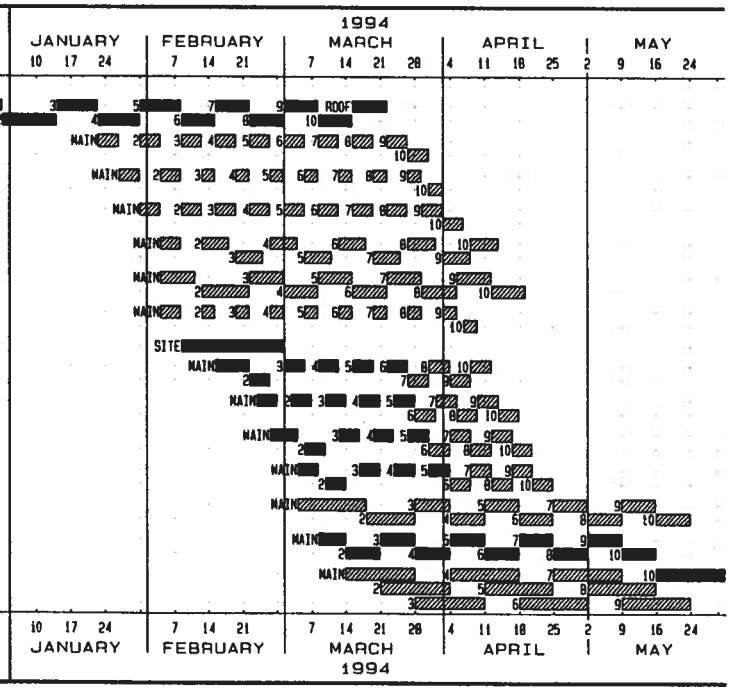
File Used: O:\REP200\PROJ12\BENYUE

Report Date: 22DEC93
Report Time: 16:30:20
Progress Date:
Revision Number: 0

Select: All Activities
Sort: Start Date
Date Selection: Act/Sch/Early
Schedule Window
Time: 13DEC93 To 30MAY94
Locations: SITE To ROOF

Start Milestone ▼ Finish Milestone ▽ Hammock Noncritical Critical % Installed Estimated [] Positive float Negative float Progress Date Procurement P<

CODE	TYPE	DESCRIPTION	Scheduled/Actual (A) Start	Finish	Dur
*G00400	SM	START SUPERSTRUCTURE	13DEC93		
*G00100	O	F/R/P/C/S SUPERSTRUCTURE	13DEC93	21MAR94	68
150100	O	ROUGH-IN SG W WATER RISERS	21JAN94	29MAR94	48
090100	O	LAYOUT WALLS/INSTL STUD SILLS	26JAN94	31MAR94	47
090200	O	INSTALL METAL STUDS	31JAN94	05APR94	47
150200	O	ROUGH-IN COPPER PLUMBING	03FEB94	12APR94	49
160100	O	ROUGH-IN ELECTRICAL	03FEB94	18APR94	53
G00200	O	INSTALL BLOCKING FOR WINDOWS	03FEB94	07APR94	46
*G00300	O	F/R/P/C/S HARD LANDSCAPING	08FEB94	28FEB94	15
*120100	O	ERECT SCAFFOLDING FOR MASONRY	15FEB94	11APR94	40
*090400	O	INSTALL EXTERNAL WALL BOARD	23FEB94	15APR94	38
*100100	O	INSTALL WINDOWS	25FEB94	19APR94	38
*090300	O	INSTALL INSULATION/VAPOUR BAR	03MAR94	22APR94	37
120200	C	BUILD BRICK WALLS	03MAR94	20MAY94	57
*090500	C	DRYWALL BOARDING	08MAR94	13MAY94	49
*090600	S	TAPE/FILL/SAND DRYWALL	14MAR94	30MAY94	55



CODE TYPE DESCRIPTION

UBC CONSTRUCTION MANAGEMENT LAB

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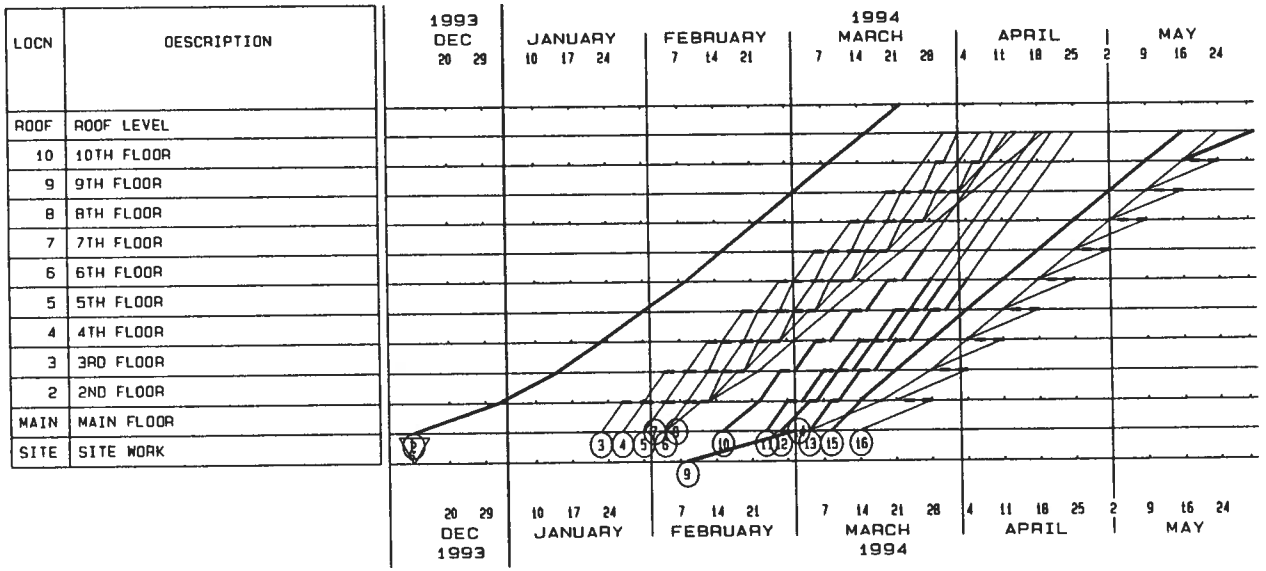
BENJAMIN YUE - EXTENDED EXAMPLE PROJECT
BASELINE SCHEDULE

File Used: D:\REP200\PROJ12\BENYUE

Select: All Activities
Sort: Start Date
Date Selection: Act/Sch/Early
Schedule Window
Time: 13DEC93 To 30MAY94
Locations: SITE To ROOF

Report Date: 22DEC93
Report Time: 16:27:49
Progress Date:
Revision Number: 0



BENJAMIN YUE - EXTENDED EXAMPLE PROJECT

BASELINE SCHEDULE

LINEAR PLANNING CHART ACTIVITY INDEX

File Used: D:\REP200\PROJ12\BENYUE

Report Date: 22DEC93
Report Time: 16:28:45
Progress Date:
Revision Number: 0

Select: All Activities
Sort: Start Date
Date Selection: Act/Sch/Early
Schedule Window
Time: 13DEC93 To 30MAY94
Locations: SITE To ROOF

KEY * Critical Activity p Activity has procurement sequence c Completed Activity Types: O Ordered, C Continuous, S Shadow, M Hammock, SM Start Milestone, FM Finish Milestone

	Code	Type	Description
* (1)	G00400	SM	START SUPERSTRUCTURE
* (2)	G00100	O	F/R/P/C/S SUPERSTRUCTURE
(3)	150100	O	ROUGH-IN SC W WATER RISERS
(4)	090100	O	LAYOUT WALLS/INSTL STUD SILLS
(5)	090200	O	INSTALL METAL STUDS
(6)	150200	O	ROUGH-IN COPPER PLUMBING
(7)	160100	O	ROUGH-IN ELECTRICAL
(8)	G00200	O	INSTALL BLOCKING FOR WINDOWS
* (9)	G00300	O	F/R/P/C/S HARD LANDSCAPING
* (10)	120100	O	ERECT SCAFFOLDING FOR MASONRY
* (11)	090400	O	INSTALL EXTERNAL WALL BOARD
* (12)	100100	O	INSTALL WINDOWS
* (13)	090300	O	INSTALL INSULATION/VAPOUR BAR
(14)	120200	C	BUILD BRICK WALLS
* (15)	090500	C	DRYWALL BOARDING
* (16)	090600	S	TAPE/FILL/SAND DRYWALL

Comment:

BENJAMIN YUE - EXTENDED EXAMPLE PROJECT

COMPARISON SCHEDULE

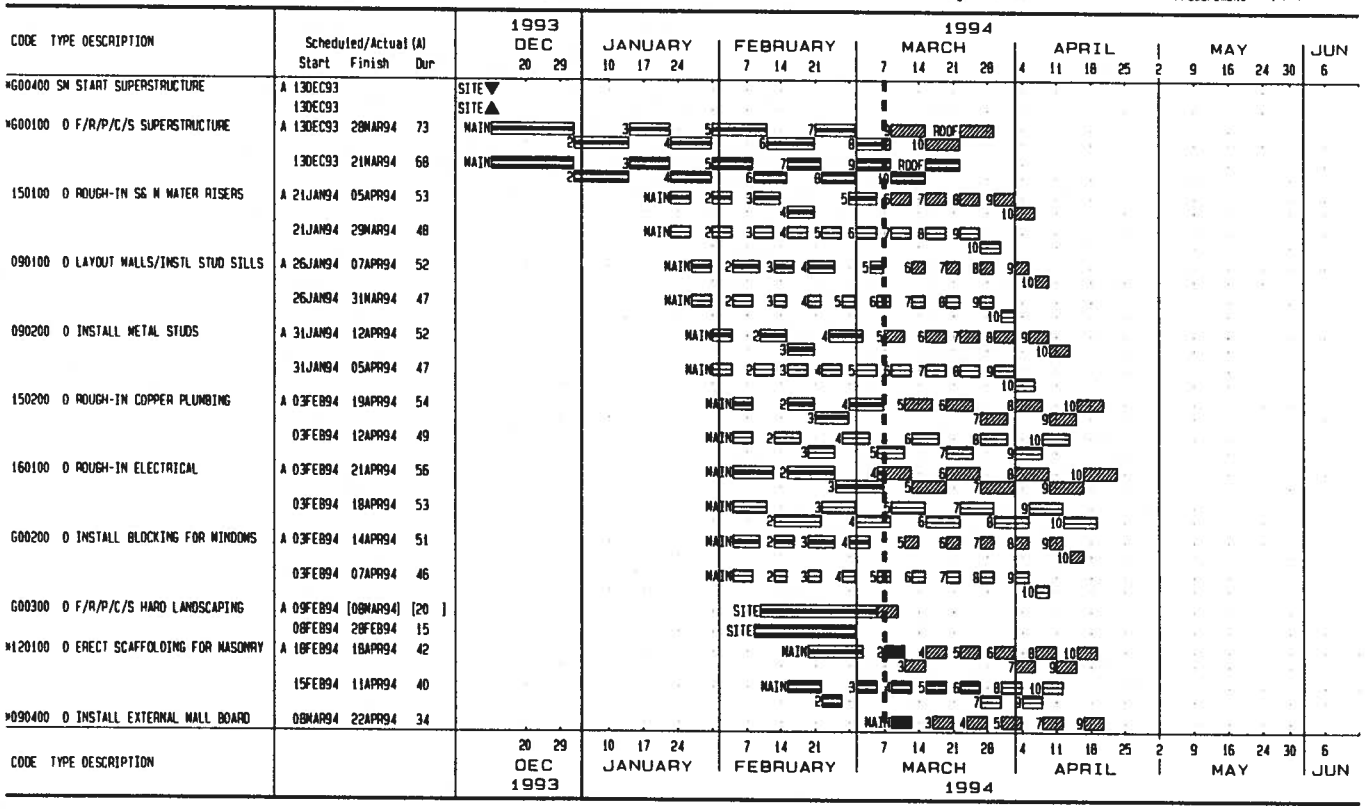
File Used: O:\REP200\PROJ13\BENYUU
Target File Used: O:\REP200\PROJ12\BENYUE

Report Date: 22DEC93
Report Time: 16:34:18
Progress Date: 04MAR94
Revision Number: 0

Select: All Activities
Sort: Start Date
Date Selection: Act/Sch/Early
Schedule Window
Time: 13DEC93 To 10JUN94
Locations: SITE To ROOF

Start Milestone (Current ▼ Target ▲) Finish Milestone (Current ▽ Target △) Hammock (Current Target) Noncritical (Current Target) Critical (Current Target) % Installed (Current Target) Estimated [] Positive float (Current Target) Negative float (Current Target) Progress Date ▮ Procurement P< >

CODE	TYPE	DESCRIPTION	Scheduled/Actual (A) Start	Finish	Dur
»G00400	SN	START SUPERSTRUCTURE	A 13DEC93		
			13DEC93		
»G00100	O	F/R/P/C/S SUPERSTRUCTURE	A 13DEC93	28MAR94	73
			13DEC93	21MAR94	68
150100	O	ROUGH-IN S& M WATER RISERS	A 21JAN94	05APR94	53
			21JAN94	29MAR94	48
090100	O	LAYOUT WALLS/INSTL STUD SILLS	A 26JAN94	07APR94	52
			26JAN94	31MAR94	47
090200	O	INSTALL METAL STUDS	A 31JAN94	12APR94	52
			31JAN94	05APR94	47
150200	O	ROUGH-IN COPPER PLUMBING	A 03FEB94	19APR94	54
			03FEB94	12APR94	49
160100	O	ROUGH-IN ELECTRICAL	A 03FEB94	21APR94	56
			03FEB94	18APR94	53
G00200	O	INSTALL BLOCKING FOR WINDOWS	A 03FEB94	14APR94	51
			03FEB94	07APR94	46
G00300	O	F/R/P/C/S HARD LANDSCAPING	A 09FEB94	[08MAR94]	[20]
			08FEB94	28FEB94	15
»120100	O	ERECT SCAFFOLDING FOR MASONRY	A 18FEB94	18APR94	42
			15FEB94	11APR94	40
»090400	O	INSTALL EXTERNAL WALL BOARD	08MAR94	22APR94	34



BENJAMIN YUE - EXTENDED EXAMPLE PROJECT

COMPARISON SCHEDULE

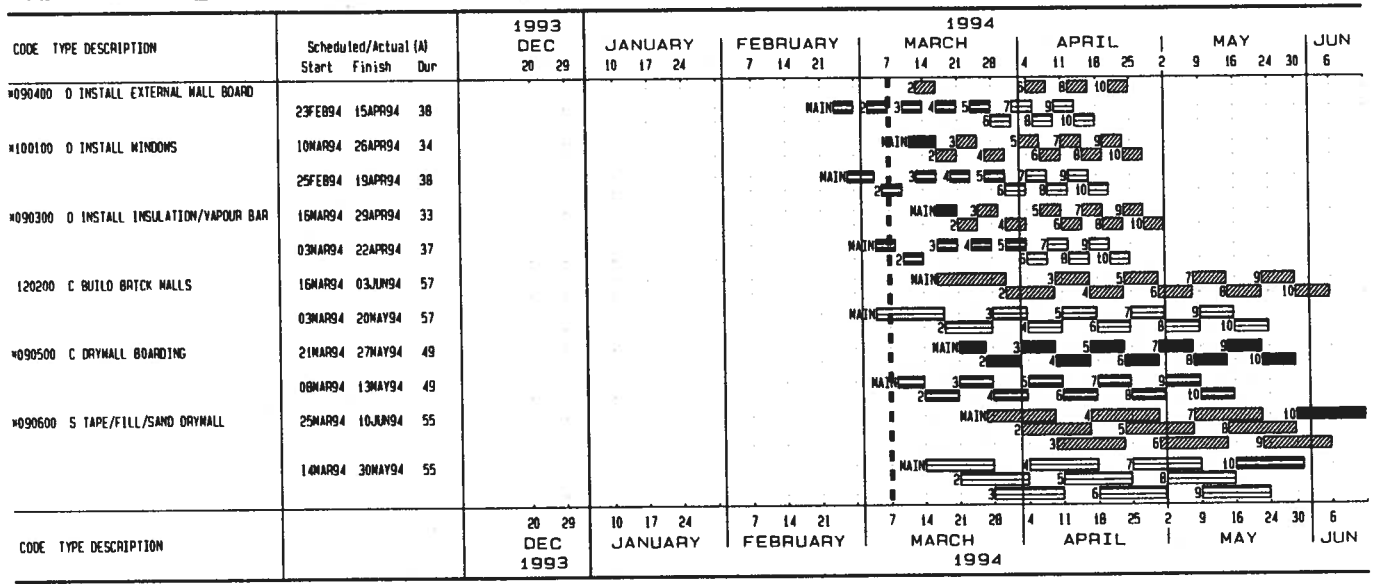
File Used: D:\REP200\PROJ13\BENYUU
Target File Used: D:\REP200\PROJ12\BENYUE

Report Date: 22DEC93
Report Time: 16:38:43
Progress Date: 04MAR94
Revision Number: 0

Select: All Activities
Sort: Start Date
Date Selection: Act/Sch/Early
Schedule Window
Time: 13DEC93 To 10JUN94
Locations: SITE To ROOF

Start Milestone (Current ▼ Target ▲) Finish Milestone (Current ▽ Target △) Hammock (Current, Target) Noncritical (Current, Target) Critical (Current, Target) % Installed (Current, Target) Estimated [] Positive float (Current, Target) Negative float Progress Date Procurement P< >

CODE	TYPE	DESCRIPTION	Scheduled/Actual (A) Start	Finish	Dur
*090400	O	INSTALL EXTERNAL WALL BOARD			
			23FEB94	15APR94	38
*100100	O	INSTALL WINDOWS	10MAR94	26APR94	34
			25FEB94	19APR94	38
*090300	O	INSTALL INSULATION/VAPOUR BAR	16MAR94	29APR94	33
			03MAR94	22APR94	37
120200	C	BUILD BRICK WALLS	16MAR94	03JUN94	57
			03MAR94	20MAY94	57
*090500	C	DRYWALL BOARDING	21MAR94	27MAY94	49
			08MAR94	13MAY94	49
*090600	S	TAPE/FILL/SAND DRYWALL	25MAR94	10JUN94	55
			14MAR94	30MAY94	55



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BENJAMIN YUE - EXTENDED EXAMPLE PROJECT

COMPARISON SCHEDULE

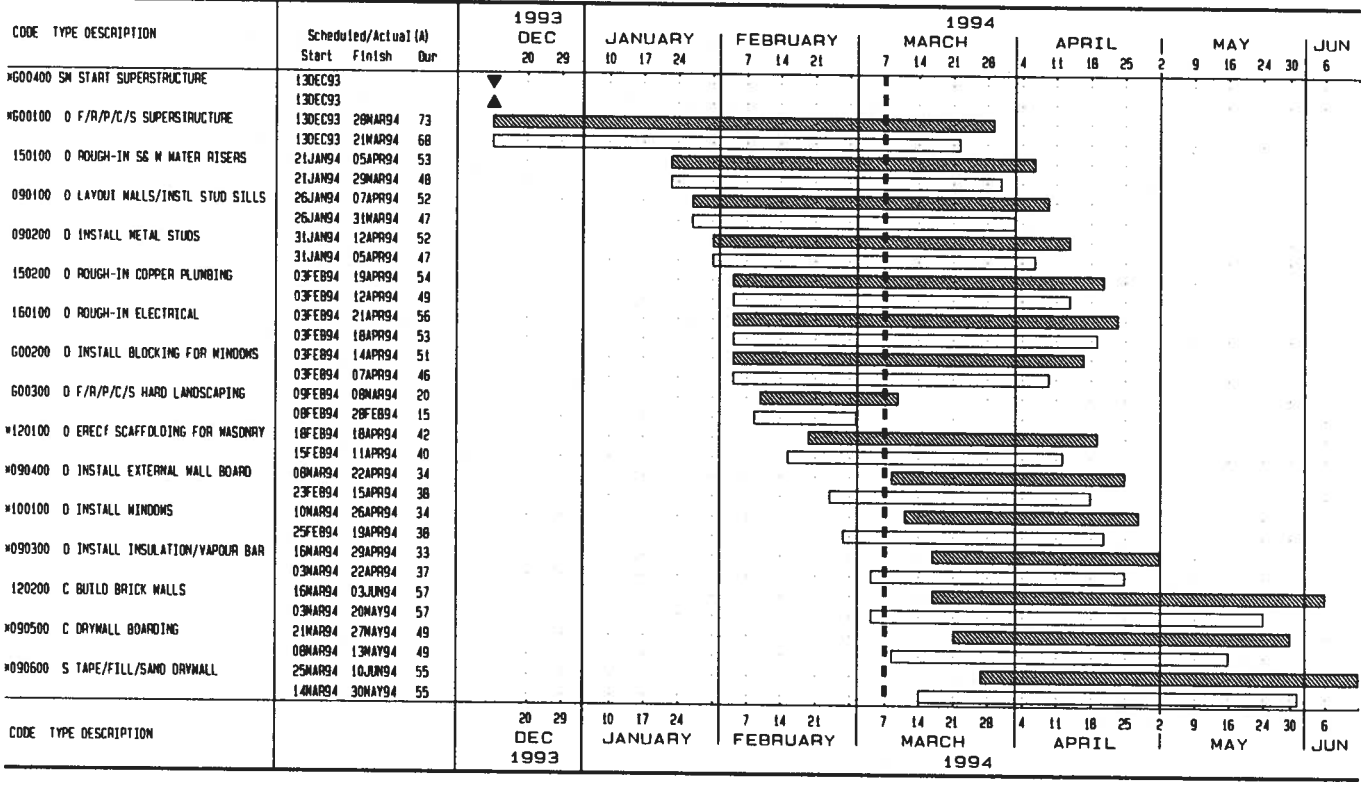
File Used: O:\REP200\PROJ13\BENYUU
Target File Used: O:\REP200\PROJ12\BENYUE

Report Date: 22DEC93
Report Time: 16:46:19
Progress Date: 04MAR94
Revision Number: 0

Select: All Activities
Sort: Start Date
Date Selection: Act/Sch/Early
Schedule Window
Time: 13DEC93 To 10JUN94
Locations: SITE To ROOF

Start Milestone (Current, Target) Finish Milestone (Current, Target) Hammock Activity (Current, Target) Estimated [] Positive float Negative float (Current, Target) Progress Date Procurement Pc >

CODE	TYPE	DESCRIPTION	Scheduled/Actual(A) Start	Finish	Dur
*G00400	SM	START SUPERSTRUCTURE	13DEC93		
			13DEC93		
*G00100	O	F/R/P/C/S SUPERSTRUCTURE	13DEC93	28MAR94	73
			13DEC93	21MAR94	68
150100	O	ROUGH-IN SS W WATER RISERS	21JAN94	05APR94	53
			21JAN94	29MAR94	48
090100	O	LAYOUT WALLS/INSTL STUD SILLS	26JAN94	07APR94	52
			26JAN94	31MAR94	47
090200	O	INSTALL METAL STUDS	31JAN94	12APR94	52
			31JAN94	05APR94	47
150200	O	ROUGH-IN COPPER PLUMBING	03FEB94	19APR94	54
			03FEB94	12APR94	49
160100	O	ROUGH-IN ELECTRICAL	03FEB94	21APR94	56
			03FEB94	18APR94	53
G00200	O	INSTALL BLOCKING FOR WINDOWS	03FEB94	14APR94	51
			03FEB94	07APR94	46
G00300	O	F/R/P/C/S HARD LANDSCAPING	09FEB94	08MAR94	20
			08FEB94	28FEB94	15
*120100	O	ERECT SCAFFOLDING FOR MASONRY	18FEB94	18APR94	42
			15FEB94	11APR94	40
*090400	O	INSTALL EXTERNAL WALL BOARD	08MAR94	22APR94	34
			23FEB94	15APR94	38
*100100	O	INSTALL WINDOWS	10MAR94	26APR94	34
			25FEB94	19APR94	38
*090300	O	INSTALL INSULATION/VAPOUR BAR	16MAR94	29APR94	33
			03MAR94	22APR94	37
120200	C	BUILD BRICK WALLS	16MAR94	03JUN94	57
			03MAR94	20MAY94	57
*090500	C	DRYWALL BOARDING	21MAR94	27MAY94	49
			08MAR94	13MAY94	49
*090600	S	TAPE/FILL/SAND DRYWALL	25MAR94	10JUN94	55
			14MAR94	30MAY94	55



CODE TYPE DESCRIPTION

APPENDIX F DATA INTERPRETATION FOR CASE STUDY EXAMPLE

UBC CONSTRUCTION MANAGEMENT LAB

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BENJAMIN YUE - EXTENDED EXAMPLE PROJECT

DAILY SITE PROJECT ANALYSIS REPORT

File Used: D:\REPZ88\PROJ29\BENYUU

Report Date: 22DEC93
Report Time: 21:44:13
Revision Number: 0
Progress Date: 04MAR94

Date Window: From 04FEB94 to 18FEB94
Method used: max-min
Weighting condition: frequency of occurrence

Total number of days lost: 25.55
Total number of manhours lost: 198.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Project Level Corrective Action No.	Description	Strength
11	Too much precipitation	0.166667	25	6.50	56	111.00	19	12		No corrective action - lack of supporting evidence	
31	Insuff./Incompl. Drawing	0.166667	9	2.25	9	17.00	10	6		No corrective action - lack of supporting evidence	
32	Drawing errors	0.111111	5	1.25	5	10.00	3	2		No corrective action - lack of supporting evidence	
34	Conflicting information	0.111111	2	0.50	0	0.00	3	2		No corrective action - lack of supporting evidence	
41	Insufficient manpower	0.277778	11	2.78	3	6.00	11	7	1.1	Hire more workers for all trades.	0.9000
									1.3	Focus labour resources on critical activities.	0.2000
									2.3	Notify owner of existing site conditions.	0.9000
									2.5	Revise the project finish date.	0.9000
44	Low skill level	0.277778	11	2.75	10	20.00	19	12		No corrective action - lack of supporting evidence	
46	Low motivation/morale	0.111111	0	0.00	4	8.00	3	2		No corrective action - lack of supporting evidence	
52	Rework (Workmanship)	0.055556	4	1.00	0	0.00	2	1		No corrective action - lack of supporting evidence	
56	Error in construction	0.111111	2	0.60	10	20.00	8	5		No corrective action - lack of supporting evidence	
57	Layout error	0.277778	23	5.75	3	6.00	15	9		No corrective action - lack of supporting evidence	
72	Poor ground conditions	0.055556	1	0.25	0	0.00	2	1		No corrective action - lack of supporting evidence	
95	Delay in award. contract	0.055556	0	2.00	0	0.00	5	3		No corrective action - lack of supporting evidence	

Aggregated Problems

Project Level Corrective Action No.	Description	Strength	Problem Number
	Do nothing - lack of evidence.	1.0000	11 31 32 34 44 46 52 56 57 72 95

UBC CONSTRUCTION MANAGEMENT LAB

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BENJAMIN YUE - EXTENDED EXAMPLE PROJECT

DAILY SITE PROJECT ANALYSIS REPORT

File Used: D:\REP288\PROJ29\BENYUU

Report Date: 22DEC93
Report Time: 21:42:47
Revision Number: 0
Progress Date: 04MAR94

Date Window: From 04FEB94 to 18FEB94
Method used: max-min
Weighting condition: time_lost

Total number of days lost: 25.55
Total number of manhours lost: 198.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Project Level Corrective Action No.	Description	Strength
11	Too much precipitation	0.166667	25	6.50	56	111.00	19	12		No corrective action - lack of supporting evidence	
31	Insuff./Incompl. Drawing	0.166667	9	2.25	9	17.00	10	6		No corrective action - lack of supporting evidence	
32	Drawing errors	0.111111	5	1.25	5	10.00	3	2		No corrective action - lack of supporting evidence	
34	Conflicting information	0.111111	2	0.50	0	0.00	3	2		No corrective action - lack of supporting evidence	
41	Insufficient manpower	0.277778	11	2.70	3	6.00	11	7	1.1	Hire more workers for all trades.	0.9000
									1.3	Focus labour resources on critical activities.	0.2000
									2.3	Notify owner of existing site conditions.	0.9000
									2.5	Revise the project finish date.	0.9000
44	Low skill level	0.277778	11	2.75	10	20.00	19	12		No corrective action - lack of supporting evidence	
46	Low motivation/morale	0.111111	0	0.00	4	8.00	3	2		No corrective action - lack of supporting evidence	
52	Rework (Workmanship)	0.055556	4	1.00	0	0.00	2	1		No corrective action - lack of supporting evidence	
56	Error in construction	0.111111	2	0.60	10	20.00	8	5		No corrective action - lack of supporting evidence	
57	Layout error	0.277778	23	5.75	3	6.00	15	9		No corrective action - lack of supporting evidence	
72	Poor ground conditions	0.055556	1	0.25	0	0.00	2	1		No corrective action - lack of supporting evidence	
95	Delay in award. contract	0.055556	8	2.00	0	0.00	5	3		No corrective action - lack of supporting evidence	

Aggregated Problems

Project Level Corrective Action No.	Description	Strength	Problem Number
	Do nothing - lack of evidence.	1.0000	11 31 32 34 44 52 56 57 72 95

BENJAMIN YUE - EXTENDED EXAMPLE PROJECT

DAILY SITE PROJECT ANALYSIS REPORT

File Used: D:\REP200\PROJ29\BENYUU

Report Date: 22DEC93
Report Time: 21:40:44
Revision Number: 0
Progress Date: 04MAR94

Date Window: From 07FEB94 to 18FEB94
Method used: max-min
Weighting condition: manhour_lost

Total number of days lost: 25.55
Total number of manhours lost: 198.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Project Level Corrective Action No.	Description	Strength
11	Too much precipitation	0.166667	25	6.50	56	111.00	19	12		No corrective action - lack of supporting evidence	
31	Insuff./Incompl. Drawing	0.166667	9	2.25	9	17.00	10	6		No corrective action - lack of supporting evidence	
32	Drawing errors	0.111111	5	1.25	5	10.00	3	2		No corrective action - lack of supporting evidence	
34	Conflicting information	0.111111	2	0.50	0	0.00	3	2		No corrective action - lack of supporting evidence	
41	Insufficient manpower	0.277778	11	2.70	3	6.00	11	7	1.1	Hire more workers for all trades.	0.9000
									1.3	Focus labour resources on critical activities.	0.2000
									2.3	Notify owner of existing site conditions.	0.9000
									2.5	Revise the project finish date.	0.9000
44	Low skill level	0.277778	11	2.75	10	20.00	19	12		No corrective action - lack of supporting evidence	
46	Low motivation/morale	0.111111	0	0.00	4	8.00	3	2		No corrective action - lack of supporting evidence	
52	Rework (Workmanship)	0.055556	4	1.00	0	0.00	2	1		No corrective action - lack of supporting evidence	
56	Error in construction	0.111111	2	0.50	10	20.00	0	5		No corrective action - lack of supporting evidence	
57	Layout error	0.277778	23	5.75	3	6.00	15	9		No corrective action - lack of supporting evidence	
72	Poor ground conditions	0.055556	1	0.25	0	0.00	2	1		No corrective action - lack of supporting evidence	
95	Delay in award. contract	0.055556	0	2.00	0	0.00	5	3		No corrective action - lack of supporting evidence	

Aggregated Problems

Project Level Corrective Action No.	Description	Strength	Problem Number
	Do nothing - lack of evidence.	1.0000	11 31 32 44 46 56 57

BENJAMIN YUE - EXTENDED EXAMPLE PROJECT

DAILY SITE ACTIVITY ANALYSIS REPORT

File Used: D:\REP200\PROJ29\BENYUU

Report Date: 22DEC93
Report Time: 22:30:42
Revision Number: 0
Progress Date: 04MAR94

Date Window: From 07FEB94 to 04MAR94
Method used: max-min
Weighting condition: frequency of occurrence
Include completed activities

Activity: 090100 LAYOUT WALLS/INSTL STUD SILLS Loc: 2
Trade responsible: DRYWALL
Start date: 03FEB94
Projected(Actual) finish date: 08FEB94
Total duration: 4 days
Remaining duration: 0 days, 0%
Free float: 0 days
Total float: 10 days
Total float/remaining duration: Undefined(Divide By 0)

Activity Attributes	Degree of Applicability
10 Internal access	: 1.00
12 Labour intensive	: 1.00
16 Design changes	: 1.00
20 Low tolerance	: 0.00
21 Learning curve effects	: 0.00
22 Design complexity	: 0.60

Total number of days lost: 1.00
Total number of manhours lost: 6.00

Problem Source No.	Description	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Activity No.	Level Corrective Action Description	Strength
32	Drawing errors	100	1.00	100	6.00	33	1	2.6	When workers are idle, reroute manpower to other activities to prevent severe manpower loss.	1.0000
								4.10	Note down in daily report dates of information requested, conversations/verbal instructions, telephone calls etc..	1.0000
								5.14	Request information/clarification from architect and/or consultant(s) ASAP.	1.0000
57	Layout error	0	0.00	0	0.00	67	2	4.14	Correct construction error at site immediately if possible.	0.6000
								4.15	Discuss with/notify subtrade(s) of required changes in layout.	1.0000
								5.14	Request information/clarification from architect and/or consultant(s) ASAP.	1.0000

Aggregated Problems

Activity No.	Level Description	Corrective Action	Strength	Problem Number
5.14		Request information/clarification from architect and/or consultant(s) ASAP.	0.3675	32 57
4.15		Discuss with/notify subtrade(s) of required changes in layout.	0.2564	57
4.14		Correct construction error at site immediately if possible.	0.1538	57
2.6		When workers are idle, reroute manpower to other activities to prevent severe manpower loss.	0.1111	32
4.18		Note down in daily report dates of information requested, conversations/verbal instructions, telephone calls etc..	0.1111	32

Activity: 090100 LAYOUT WALLS/INSTL STUD SILLS Loc: 3
Trade responsible: DRYWALL
Start date: 11FEB94
Projected(Actual) finish date: 15FEB94
Total duration: 3 days
Remaining duration: 0 days, 0%
Free float: 0 days
Total float: 12 days
Total float/remaining duration: Undefined(Divide By 0)

Activity Attributes	Degree of Applicability
10 Internal access	: 1.00
12 Labour intensive	: 1.00
16 Design changes	: 1.00
20 Low tolerance	: 0.00
21 Learning curve effects	: 0.00
22 Design complexity	: 0.60

Total number of days lost: 0.75
Total number of manhours lost: 0.00

Problem No.	Source Description	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Activity No.	Level Description	Corrective Action	Strength
57	Layout error	100	0.75		0.00	100	2	4.14		Correct construction error at site immediately if possible.	0.6000
								4.15		Discuss with/notify subtrade(s) of required changes in layout.	1.0000
								5.14		Request information/clarification from architect and/or consultant(s) ASAP.	1.0000

Aggregated Problems

Activity No.	Level Description	Corrective Action	Strength	Problem Number
4.15		Discuss with/notify subtrade(s) of required changes in layout.	0.3846	57
5.14		Request information/clarification from architect and/or consultant(s) ASAP.	0.3846	57
4.14		Correct construction error at site immediately if	0.2308	57

possible.

Activity: 090100 LAYOUT WALLS/INSTL STUD SILLS Loc: 1
  Trade responsible: DRYWALL
  Start date: 18FEB94
  Projected(Actual) finish date: 23FEB94
  Total duration: 4 days
  Remaining duration: 0 days, 0%
  Free float: 0 days
  Total float: 15 days
  Total float/remaining duration: Undefined(Divide By 0)

Activity Attributes	Degree of Applicability
10 Internal access	: 1.00
12 Labour intensive	: 1.00
16 Design changes	: 1.00
20 Low tolerance	: 0.00
21 Learning curve effects	: 0.00
22 Design complexity	: 0.60

  Total number of days lost: 0.25
  Total number of manhours lost: 0.00

Problem Source No.	Description	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Activity Level Corrective Action No.	Description	Strength
41	Insufficient manpower	100	0.25		0.00	100	2	4.3	Increase the remaining duration on the activity.	1.0000
								9.1	Do nothing.	1.0000

Aggregated Problems

Activity Level Corrective Action No.	Description	Strength	Problem Number
4.3	Increase the remaining duration on the activity.	0.5000	41
9.1	Do nothing.	0.5000	41

Activity: 090200 INSTALL METAL STUDS Loc: 2
  Trade responsible: DRYWALL
  Start date: 09FEB94
  Projected(Actual) finish date: 14FEB94
  Total duration: 4 days
  Remaining duration: 0 days, 0%
  Free float: 0 days
  Total float: 9 days
  Total float/remaining duration: Undefined(Divide By 0)

Activity Attributes	Degree of Applicability
10 Internal access	: 1.00
12 Labour intensive	: 1.00
16 Design changes	: 1.00
21 Learning curve effects	: 0.00
22 Design complexity	: 0.40

  Total number of days lost: 0.50
  Total number of manhours lost: 0.00

Problem Source No.	Description	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Activity Level Corrective Action No.	Description	Strength
41	Insufficient manpower	100	0.50		0.00	50	2	2.2	Reallocate manpower from preferably a buffer or non-critical activity (XXSSTT) to activity XXYYZZ.	0.6000
								9.1	Do nothing.	0.0000
44	Low skill level	0	0.00		0.00	50	2	2.4	Discuss with subtrade foreman workforce performance.	1.0000

Aggregated Problems

Activity Level Corrective Action No.	Description	Strength	Problem Number
2.4	Discuss with subtrade foreman workforce performance.	0.7857	44
2.2	Reallocate manpower from preferably a buffer or non-critical activity (XXSSTT) to activity XXYYZZ.	0.2143	41

Activity: 090200 INSTALL METAL STUDS Loc: 3
Trade responsible: DRYWALL
Start date: 15FEB94
Projected(Actual) finish date: 18FEB94
Total duration: 4 days
Remaining duration: 0 days, 0%
Free float: 0 days
Total float: 12 days
Total float/remaining duration: Undefined(Divide By 0)

Activity Attributes	Degree of Applicability
10 Internal access	: 1.00
12 Labour intensive	: 1.00
16 Design changes	: 1.00
21 Learning curve effects	: 0.00
22 Design complexity	: 0.40

Total number of days lost: 1.75
Total number of manhours lost: 0.00

Problem Source No.	Description	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Activity Level Corrective Action No.	Description	Strength
44	Low skill level	43	0.75		0.00	80	4	2.3	Upgrade untrained personnel to trained personnel.	0.0000
								2.4	Discuss with subtrade foreman workforce performance.	1.0000
								2.9	Hire more experienced workers to lead inexperienced workers.	1.0000
52	Rework (Workmanship)	57	1.00		0.00	20	1	2.3	Upgrade untrained personnel to trained personnel.	1.0000
								4.3	Increase the remaining duration on the activity.	0.5000
								4.8	Increase or improve supervision.	1.0000
								7.6	Open a backcharge to a subtrade or supplier for acceleration.	1.0000

Aggregated Problems

Activity Level Corrective Action No.	Description	Strength	Problem Number
2.3	Upgrade untrained personnel to trained personnel.	0.2857	44 52
2.4	Discuss with subtrade foreman workforce performance.	0.2857	44
2.9	Hire more experienced workers to lead inexperienced workers.	0.2857	44
4.8	Increase or improve supervision.	0.0571	52
7.6	Open a backcharge to a subtrade or supplier for acceleration.	0.0571	52
4.3	Increase the remaining duration on the activity.	0.0286	52

Activity: 090200 INSTALL METAL STUDS Loc: 4
Trade responsible: DRYWALL
Start date: 23FEB94
Projected(Actual) finish date: 01MAR94
Total duration: 5 days
Remaining duration: 0 days, 0%
Free float: 0 days
Total float: 14 days
Total float/remaining duration: Undefined(Divide By 0)

Activity Attributes	Degree of Applicability
10 Internal access	: 1.00
12 Labour intensive	: 1.00
16 Design changes	: 1.00
21 Learning curve effects	: 0.00
22 Design complexity	: 0.40

Total number of days lost: 1.75
Total number of manhours lost: 0.00

Problem Source No.	Description	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Activity Level Corrective Action No.	Description	Strength
41	Insufficient manpower	71	1.25		0.00	60	3	4.3	Increase the remaining duration on the activity.	1.0000
								9.1	Do nothing.	1.0000
56	Error in construction	29	0.50		0.00	40	2	5.10	Contact relevant parties for correction and/or information.	1.0000

Aggregated Problems

Activity Level Corrective Action No.	Description	Strength	Problem Number
5.10	Contact relevant parties for correction and/or information.	0.7000	56
4.3	Increase the remaining duration on the activity.	0.3000	41

Activity: 120100 ERECT SCAFFOLDING FOR MASONRY Loc: MAIN
Trade responsible: MASONRY
Start date: 18FEB94
Projected(Actual) finish date: 01MAR94
Total duration: 8 days

Remaining duration: 0 days, 0%
Free float: 0 days
Total float: -2 days
Total float/remaining duration: Undefined(Divide By 0)

Activity Attributes	Degree of Applicability
6 Wind	: 0.00
7 Ground conditions	: 0.00
8 Storage on site	: 0.40
9 Site congestion	: 0.00
11 External access	: 1.00
12 Labour intensive	: 1.00
17 High inspection	: 0.50
21 Learning curve effects	: 0.40

Total number of days lost: 1.75
Total number of manhours lost: 0.00

Problem Source No.	Description	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Activity No.	Level Corrective Action Description	Strength
72	Poor ground conditions	43	0.75		0.00	60	3	3.1	Conduct more on-site soil investigations.	0.0000
								4.3	Increase the remaining duration on the activity.	0.0000
								6.2	Notify the Owner under a contract clause for unexpected conditions (ground conditions, utilities).	0.0000
								7.3	Open a delay claim.	0.0000
								7.11	Open a claim for conditions not covered by the contract.	0.0000
								9.1	Do nothing.	0.0000
95	Delay in award. contract	57	1.00		0.00	40	2		No corrective action - lack of supporting evidence	

Aggregated Problems

Activity Level Corrective Action No.	Description	Strength	Problem Number
	Do nothing - lack of evidence.	1.0000	95

Activity: 150100 ROUGH-IN SB W WATER RISERS Loc: 3
Trade responsible: MECHANICAL
Start date: 08FEB94
Projected(Actual) finish date: 11FEB94
Total duration: 4 days
Remaining duration: 0 days, 0%
Free float: 0 days
Total float: 12 days
Total float/remaining duration: Undefined(Divide By 0)

Activity Attributes	Degree of Applicability
10 Internal access	: 1.00
12 Labour intensive	: 0.50
16 Design changes	: 1.00
17 High inspection	: 0.00
19 Controlled environment	: 0.50
20 Low tolerance	: 0.20
21 Learning curve effects	: 0.50
22 Design complexity	: 0.50

Total number of days lost: 3.00
Total number of manhours lost: 0.00

Problem Source No.	Description	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Activity Level Corrective Action No.	Description	Strength
S7	Layout error	100	3.00		0.00	100	3	4.14	Correct construction error at site immediately if possible.	0.6000
								4.15	Discuss with/notify subtrade(s) of required changes in layout.	1.0000
								5.14	Request information/clarification from architect and/or consultant(s) ASAP.	1.0000

Aggregated Problems

Activity Level Corrective Action No.	Description	Strength	Problem Number
4.15	Discuss with/notify subtrade(s) of required changes in layout.	0.3846	S7
5.14	Request information/clarification from architect and/or consultant(s) ASAP.	0.3846	S7
4.14	Correct construction error at site immediately if possible.	0.2308	S7

Activity: 158100 ROUGH-IN S& V WATER RISERS Loc: 4
Trade responsible: MECHANICAL
Start date: 15FEB94
Projected(Actual) finish date: 18FEB94
Total duration: 4 days
Remaining duration: 0 days, 0%
Free float: 0 days
Total float: 12 days
Total float/remaining duration: Undefined(Divide By 0)

Activity Attributes	Degree of Applicability
10 Internal access	: 1.00
12 Labour intensive	: 0.50
16 Design changes	: 1.00
17 High inspection	: 0.00
19 Controlled environment	: 0.50
20 Low tolerance	: 0.20
21 Learning curve effects	: 0.50
22 Design complexity	: 0.50

Total number of days lost: 1.00
Total number of manhours lost: 0.00

Problem Source No.	Description	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Activity Level Corrective Action No.	Description	Strength
S7	Layout error	100	1.00		0.00	100	1	4.14	Correct construction error at site immediately if possible.	0.6000
								4.15	Discuss with/notify subtrade(s) of required changes in layout.	1.0000
								5.14	Request information/clarification from architect and/or consultant(s) ASAP.	1.0000

Aggregated Problems

Activity Level Corrective Action No.	Description	Strength	Problem Number
4.15	Discuss with/notify subtrade(s) of required changes in layout.	0.3846	57
5.14	Request information/clarification from architect and/or consultant(s) ASAP.	0.3846	57
4.14	Correct construction error at site immediately if possible.	0.2308	57

Activity: 150100 ROUGH-IN S& W WATER RISERS Loc: 5
Trade responsible: MECHANICAL
Start date: 28FEB94
Projected(Actual) finish date: 03MAR94
Total duration: 4 days
Remaining duration: 0 days, 0%
Free float: 0 days
Total float: 12 days
Total float/remaining duration: Undefined(Divide By 0)

Activity Attributes	Degree of Applicability
10 Internal access	: 1.00
12 Labour intensive	: 0.50
16 Design changes	: 1.00
17 High inspection	: 0.00
19 Controlled environment	: 0.50
20 Low tolerance	: 0.20
21 Learning curve effects	: 0.50
22 Design complexity	: 0.50

Total number of days lost: 0.50
Total number of manhours lost: 0.00

Problem Source No.	Description	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Activity Level Corrective Action No.	Description	Strength
41	Insufficient manpower	100	0.50		0.00	100	1	4.3	Increase the remaining duration on the activity.	0.5000
								9.1	Do nothing.	0.5000

Aggregated Problems

Activity Level Corrective Action No.	Description	Strength	Problem Number
4.3	Increase the remaining duration on the activity.	0.5000	41
9.1	Do nothing.	0.5000	41

Activity: 150200 ROUGH-IN COPPER PLUMBING Loc: 2
Trade responsible: MECHANICAL
Start date: 15FEB94
Projected(Actual) finish date: 18FEB94
Total duration: 4 days
Remaining duration: 0 days, 0%
Free float: 1 days
Total float: 12 days

Total float/remaining duration: Undefined(Divide By 0)

Activity Attributes	Degree of Applicability
10 Internal access	: 1.00
12 Labour intensive	: 0.90
16 Design changes	: 0.90
17 High inspection	: 0.80
19 Controlled environment	: 0.70
21 Learning curve effects	: 0.50
22 Design complexity	: 0.50

Total number of days lost: 1.25
Total number of manhours lost: 0.00

Problem Source No.	Description	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Activity Level Corrective Action No.	Description	Strength
34	Conflicting information	20	0.25		0.00	33	1	2.6	When workers are idle, reroute manpower to other activities to prevent severe manpower loss.	0.9000
								4.2	Do secondary work on the activity.	0.9000
								4.12	Monitor the activity closely.	0.9000
								5.9	Improve architect/engineer/consultant coordination.	0.9000
								5.10	Contact relevant parties for correction and/or information.	0.9000
41	Insufficient manpower	80	1.00		0.00	67	2	4.3	Increase the remaining duration on the activity.	0.9000
								9.1	Do nothing.	0.9000

Aggregated Problems

Activity Level Corrective Action No.	Description	Strength	Problem Number
4.12	Monitor the activity closely.	0.4000	34
4.3	Increase the remaining duration on the activity.	0.3333	41
2.6	When workers are idle, reroute manpower to other activities to prevent severe manpower loss.	0.0667	34
4.2	Do secondary work on the activity.	0.0667	34
5.9	Improve architect/engineer/consultant coordination.	0.0667	34
5.10	Contact relevant parties for correction and/or information.	0.0667	34

Activity: 150200 ROUGH-IN COPPER PLUMBING Loc: 3
Trade responsible: MECHANICAL
Start date: 21FEB94
Projected(Actual) finish date: 25FEB94
Total duration: 5 days
Remaining duration: 0 days, 0%
Free float: 1 days
Total float: 16 days
Total float/remaining duration: Undefined(Divide By 0)

Activity Attributes	Degree of Applicability
10 Internal access	: 1.00
12 Labour intensive	: 0.90
16 Design changes	: 0.90
17 High inspection	: 0.80

19 Controlled environment : 0.70
21 Learning curve effects : 0.50
22 Design complexity : 0.50

Total number of days lost: 0.03
Total number of manhours lost: 0.00

Problem Source No. Description	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Activity Level Corrective Action No. Description	Strength
41 Insufficient manpower	100	0.03		0.00	100	3	2.2 Reallocate manpower from preferably a buffer or non-critical activity (XXSSTT) to activity XXYYZZ.	0.6000
							9.1 Do nothing.	0.8000

Aggregated Problems

Activity Level Corrective Action No. Description	Strength	Problem Number
9.1 Do nothing.	1.0000	41

Activity: 150200 ROUGH-IN COPPER PLUMBING Loc: 4
Trade responsible: MECHANICAL
Start date: 28FEB94
Projected(Actual) finish date: 04MAR94
Total duration: 5 days
Remaining duration: 0 days, 0%
Free float: 4 days
Total float: 16 days
Total float/remaining duration: Undefined(Divide By 0)

Activity Attributes	Degree of Applicability
10 Internal access	1.00
12 Labour intensive	0.90
16 Design changes	0.90
17 High inspection	0.80
19 Controlled environment	0.70
21 Learning curve effects	0.50
22 Design complexity	0.50

Total number of days lost: 2.00
Total number of manhours lost: 0.00

Problem Source No. Description	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Activity Level Corrective Action No. Description	Strength
41 Insufficient manpower	100	2.00		0.00	100	2	2.2 Reallocate manpower from preferably a buffer or non-critical activity (XXSSTT) to activity XXYYZZ.	0.6000
							9.1 Do nothing.	0.8000

Aggregated Problems

Activity Level Corrective Action No. Description	Strength	Problem Number
9.1 Do nothing.	1.0000	41

16 Design changes : 0.90
17 High inspection : 0.80
19 Controlled environment : 0.70
21 Learning curve effects : 0.50
22 Design complexity : 0.60

Total number of days lost: 0.75
Total number of manhours lost: 0.00

Problem Source No.	Description	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Activity Level Corrective Action No.	Description	Strength
31	Insuff./Incompl. Drawing	67	0.50		0.00	50	1	4.1	Postpone the activity.	0.9000
								4.3	Increase the remaining duration on the activity.	0.9000
								5.9	Improve architect/engineer/consultant coordination.	0.5000
								7.2	Issue a memo to the party concerned to request drawing completion.	0.9000
34	Conflicting information	33	0.25		0.00	50	1	2.6	When workers are idle, reroute manpower to other activities to prevent severe manpower loss.	0.9000
								4.2	Do secondary work on the activity.	0.9000
								4.12	Monitor the activity closely.	0.9000
								5.9	Improve architect/engineer/consultant coordination.	0.9000
								5.10	Contact relevant parties for correction and/or information.	0.9000

Aggregated Problems

Activity Level Corrective Action No.	Description	Strength	Problem Number
5.9	Improve architect/engineer/consultant coordination.	0.1701	31 34
4.1	Postpone the activity.	0.1406	31
4.3	Increase the remaining duration on the activity.	0.1406	31
7.2	Issue a memo to the party concerned to request drawing completion.	0.1406	31
2.6	When workers are idle, reroute manpower to other activities to prevent severe manpower loss.	0.1000	34
4.2	Do secondary work on the activity.	0.1000	34
4.12	Monitor the activity closely.	0.1000	34
5.10	Contact relevant parties for correction and/or information.	0.1000	34

Activity: 160100 ROUGH-IN ELECTRICAL Loc: 3
Trade responsible: ELECTRICAL
Start date: 24FEB94
Projected(Actual) finish date: 04MAR94
Total duration: 7 days
Remaining duration: 0 days, 0%
Free float: 0 days
Total float: 11 days
Total float/remaining duration: Undefined(Divide By 0)

Activity Attributes Degree of Applicability
18 Internal access : 1.00
12 Labour intensive : 0.90

Activity: 168100 ROUGH-IN ELECTRICAL Loc: MAIN
Trade responsible: ELECTRICAL
Start date: 03FEB94
Projected(Actual) finish date: 10FEB94
Total duration: 6 days
Remaining duration: 0 days, 0%
Free float: 1 days
Total float: 11 days
Total float/remaining duration: Undefined(Divide By 0)

Activity Attributes	Degree of Applicability
10 Internal access	: 1.00
12 Labour intensive	: 0.90
16 Design changes	: 0.90
17 High inspection	: 0.80
19 Controlled environment	: 0.70
21 Learning curve effects	: 0.50
22 Design complexity	: 0.60

Total number of days lost: 1.00
Total number of manhours lost: 10.00

Problem Source No.	Description	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Activity Level Corrective Action No.	Description	Strength
31	Insuff./Incompl. Drawing	100	1.00	100	10.00	100	2	4.1	Postpone the activity.	0.9000
								4.3	Increase the remaining duration on the activity.	0.9000
								5.9	Improve architect/engineer/consultant coordination.	0.5000
								7.2	Issue a memo to the party concerned to request drawing completion.	0.9000

Aggregated Problems

Activity Level Corrective Action No.	Description	Strength	Problem Number
4.1	Postpone the activity.	0.2812	31
4.3	Increase the remaining duration on the activity.	0.2812	31
7.2	Issue a memo to the party concerned to request drawing completion.	0.2812	31
5.9	Improve architect/engineer/consultant coordination.	0.1563	31

Activity: 168100 ROUGH-IN ELECTRICAL Loc: 2
Trade responsible: ELECTRICAL
Start date: 15FEB94
Projected(Actual) finish date: 23FEB94
Total duration: 7 days
Remaining duration: 0 days, 0%
Free float: 0 days
Total float: 13 days
Total float/remaining duration: Undefined(Divide By 0)

Activity Attributes	Degree of Applicability
10 Internal access	: 1.00
12 Labour intensive	: 0.90

16 Design changes : 0.90
17 High inspection : 0.80
19 Controlled environment : 0.70
21 Learning curve effects : 0.50
22 Design complexity : 0.60

Total number of days lost: 2.25
Total number of manhours lost: 0.00

Problem Source No.	Description	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Activity Level Corrective Action No.	Description	Strength
41	Insufficient manpower	100	2.25		0.00	100	3	4.3	Increase the remaining duration on the activity.	0.9000
								9.1	Do nothing.	0.9000

Aggregated Problems

Activity Level Corrective Action No.	Description	Strength	Problem Number
4.3	Increase the remaining duration on the activity.	0.5000	41
9.1	Do nothing.	0.5000	41

Activity: C80100 F/R/P/C/S SUPERSTRUCTURE Loc: 5
Trade responsible: GENERAL CONTRACTOR
Start date: 31JAN94
Projected(Actual) finish date: 09FEB94
Total duration: 8 days
Remaining duration: 8 days, 0%
Free float: 0 days
Total float: -2 days
Total float/remaining duration: Undefined(Divide By 0)

Activity Attributes	Degree of Applicability
1 High precipitation	1.00
3 High temperature	0.60
4 Low temperature	1.00
6 Wind	0.80
8 Storage on site	1.00
11 External access	1.00
12 Labour intensive	0.90
13 Equipment intensive	0.80
15 Innovative methods	0.80
16 Design changes	1.00
17 High inspection	1.00
18 Contract provision	1.00
20 Low tolerance	0.70
21 Learning curve effects	0.90
22 Design complexity	1.00

Total number of days lost: 2.00
Total number of manhours lost: 70.00

Problem Source No.	Description	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Activity Level Corrective Action No.	Description	Strength
11	Too much precipitation	100	2.00	100	70.00	100	2	1.1	Provide a protected environment or shelter.	0.4000

								1.2	Postpone the activity to a time window with better anticipated weather conditions.	1.0000
								4.3	Increase the remaining duration on the activity.	1.0000
								6.1	Pursue a project time extension for unreasonable delay beyond contractor's control.	0.8000
								9.1	Do nothing.	0.7200

Aggregated Problems

Activity No.	Level Corrective Action Description	Strength	Problem Number
6.1	Pursue a project time extension for unreasonable delay beyond contractor's control.	0.3878	11
1.2	Postpone the activity to a time window with better anticipated weather conditions.	0.2551	11
4.3	Increase the remaining duration on the activity.	0.2551	11
1.1	Provide a protected environment or shelter.	0.1020	11

Activity: G80100 F/R/P/C/S SUPERSTRUCTURE Loc: 6
Trade responsible: GENERAL CONTRACTOR
Start date: 18FEB94
Projected(Actual) finish date: 18FEB94
Total duration: 7 days
Remaining duration: 0 days, 0%
Free float: 0 days
Total float: -4 days
Total float/remaining duration: Undefined(Divide By 0)

Activity Attributes	Degree of Applicability
1 High precipitation	: 1.00
3 High temperature	: 0.60
4 Low temperature	: 1.00
6 Wind	: 0.00
8 Storage on site	: 1.00
11 External access	: 1.00
12 Labour intensive	: 0.90
13 Equipment intensive	: 0.00
15 Innovative methods	: 0.00
16 Design changes	: 1.00
17 High inspection	: 1.00
18 Contract provision	: 1.00
20 Low tolerance	: 0.70
21 Learning curve effects	: 0.90
22 Design complexity	: 1.00

Total number of days lost: 2.55
Total number of manhours lost: 52.00

Problem Source No.	Description	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Activity Level Corrective Action No.	Description	Strength
11	Too much precipitation	78	2.00	46	24.00	42	5	1.1	Provide a protected environment or shelter.	0.4000
								1.2	Postpone the activity to a time window with better anticipated weather conditions.	1.0000
								4.3	Increase the remaining duration on the activity.	1.0000
								6.1	Pursue a project time extension for unreasonable delay beyond contractor's control.	0.8000

41 Insufficient manpower	8	0.20	12	6.00	8	1	9.1	Do nothing.	0.7200
							4.3	Increase the remaining duration on the activity.	0.9000
							9.1	Do nothing.	0.9000
44 Low skill level	8	0.00	8	4.00	17	2	2.4	Discuss with subtrade foreman workforce performance.	0.9000
46 Low motivation/morale	8	0.00	8	4.00	8	1		No corrective action - lack of supporting evidence	
56 Error in construction	14	0.35	27	14.00	25	3	2.1	Seek additional tradesmen and allocate them to activity XXYYZZ.	0.9000
							2.2	Reallocate manpower from preferably a buffer or non-critical activity (XXSSTT) to activity XXYYZZ.	0.9000
							4.9	Reallocate tools/equipment from preferably a buffer or non-critical activity to a critical one.	0.5000
							4.10	Purchase or rent backup equipment/tools.	0.8000
							4.20	See if an alternative design can be used rather than performing remedial work to correct problems.	0.8000
							4.21	Allocate time for rework to correct error.	0.9000
							5.2	Employ a quality control program.	1.0000
							5.10	Contact relevant parties for correction and/or information.	1.0000
							5.17	Determine the impact of construction error on the project; if critical, seek additional trade/ workers for rework.	1.0000
							7.3	Open a delay claim.	0.5000

Aggregated Problems

Activity No.	Level Description	Corrective Action	Strength	Problem Number
6.1		Pursue a project time extension for unreasonable delay beyond contractor's control.	0.2066	11
2.4		Discuss with subtrade foreman workforce performance.	0.1667	44
4.3		Increase the remaining duration on the activity.	0.1488	11 41
1.2		Postpone the activity to a time window with better anticipated weather conditions.	0.1063	11
1.1		Provide a protected environment or shelter.	0.0425	11
5.2		Employ a quality control program.	0.0301	56
5.10		Contact relevant parties for correction and/or information.	0.0301	56
5.17		Determine the impact of construction error on the project; if critical, seek additional trade/ workers for rework.	0.0301	56
2.1		Seek additional tradesmen and allocate them to activity XXYYZZ.	0.0271	56
2.2		Reallocate manpower from preferably a buffer or non-critical activity (XXSSTT) to activity XXYYZZ.	0.0271	56
4.21		Allocate time for rework to correct error.	0.0271	56
4.10		Purchase or rent backup equipment/tools.	0.0241	56
4.20		See if an alternative design can be used rather than performing remedial work to correct problems.	0.0241	56
4.9		Reallocate tools/equipment from preferably a buffer or non-critical activity to a critical one.	0.0151	56
7.3		Open a delay claim.	0.0151	56

Activity: C00100 F/R/P/C/S SUPERSTRUCTURE Loc: 7
Trade responsible: GENERAL CONTRACTOR
Start date: 21FEB94
Projected(Actual) finish date: 28FEB94

Total duration: 6 days
Remaining duration: 0 days, 0%
Free float: 0 days
Total float: -1 days
Total float/remaining duration: Undefined(Divide By 0)

Activity Attributes	Degree of Applicability
1 High precipitation	: 1.00
3 High temperature	: 0.60
4 Low temperature	: 1.00
6 Wind	: 0.00
8 Storage on site	: 1.00
11 External access	: 1.00
12 Labour intensive	: 0.90
13 Equipment intensive	: 0.00
15 Innovative methods	: 0.00
16 Design changes	: 1.00
17 High inspection	: 1.00
18 Contract provision	: 1.00
20 Low tolerance	: 0.70
21 Learning curve effects	: 0.90
22 Design complexity	: 1.00

Total number of days lost: 1.10
Total number of manhours lost: 19.50

Problem Source No.	Description	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Activity No.	Level Corrective Action Description	Strength
11	Too much precipitation	0	0.00	62	12.00	29	2	1.1	Provide a protected environment or shelter.	0.4000
								1.2	Postpone the activity to a time window with better anticipated weather conditions.	1.0000
								4.3	Increase the remaining duration on the activity.	1.0000
								6.1	Pursue a project time extension for unreasonable delay beyond contractor's control.	0.8000
								9.1	Do nothing.	0.7200
41	Insufficient manpower	73	0.00	0	0.00	43	3	4.3	Increase the remaining duration on the activity.	0.9000
								9.1	Do nothing.	0.9000
56	Error in construction	27	0.30	38	7.50	29	2	2.1	Seek additional tradesmen and allocate them to activity XXYYZZ.	0.9000
								2.2	Reallocate manpower from preferably a buffer or non-critical activity (XXSSTT) to activity XXYYZZ.	0.9000
								4.9	Reallocate tools/equipment from preferably a buffer or non-critical activity to a critical one.	0.5000
								4.10	Purchase or rent backup equipment/tools.	0.0000
								4.20	See if an alternative design can be used rather than performing remedial work to correct problems.	0.0000
								4.21	Allocate time for rework to correct error.	0.9000
								5.2	Employ a quality control program.	1.0000
								5.10	Contact relevant parties for correction and/or information.	1.0000
								5.17	Determine the impact of construction error on the project: if critical, seek additional trade/ workers for rework.	1.0000
								7.3	Open a delay claim.	0.5000

Aggregated Problems

Activity No.	Level Corrective Action Description	Strength	Problem Number
6.1	Pursue a project time extension for unreasonable delay beyond contractor's control.	0.3251	11
4.3	Increase the remaining duration on the activity.	0.2872	11 41
1.2	Postpone the activity to a time window with better anticipated weather conditions.	0.0729	11
5.2	Employ a quality control program.	0.0344	56
5.10	Contact relevant parties for correction and/or information.	0.0344	56
5.17	Determine the impact of construction error on the project; if critical, seek additional trade/ workers for rework.	0.0344	56
2.1	Seek additional tradesmen and allocate them to activity XXYYZZ.	0.0310	56
2.2	Reallocate manpower from preferably a buffer or non-critical activity (XXSSTT) to activity XXYYZZ.	0.0310	56
4.21	Allocate time for rework to correct error.	0.0310	56
1.1	Provide a protected environment or shelter.	0.0292	11
4.10	Purchase or rent backup equipment/tools.	0.0275	56
4.20	See if an alternative design can be used rather than performing remedial work to correct problems.	0.0275	56
4.9	Reallocate tools/equipment from preferably a buffer or non-critical activity to a critical one.	0.0172	56
7.3	Open a delay claim.	0.0172	56

Activity: G00100 F/R/P/C/S SUPERSTRUCTURE Loc: 0
Trade responsible: GENERAL CONTRACTOR
Start date: 01MAR94
Projected(Actual) finish date: 07MAR94
Total duration: 5 days
Remaining duration: 1 days, 20%
Free float: 0 days
Total float: 4 days
Total float/remaining duration: 4.00

Activity Attributes	Degree of Applicability
1 High precipitation	: 1.00
3 High temperature	: 0.60
4 Low temperature	: 1.00
6 Wind	: 0.00
8 Storage on site	: 1.00
11 External access	: 1.00
12 Labour intensive	: 0.90
13 Equipment intensive	: 0.00
15 Innovative methods	: 0.00
16 Design changes	: 1.00
17 High inspection	: 1.00
18 Contract provision	: 1.00
20 Low tolerance	: 0.70
21 Learning curve effects	: 0.90
22 Design complexity	: 1.00

Total number of days lost: 0.50
Total number of manhours lost: 4.00

Problem Source No.	Description	% total days lost	total days lost	% total whrs lost	total whrs lost	% occur	total occur	Activity Level Corrective Action No.	Description	Strength
11	Too much precipitation	50	0.25	100	4.00	50	1	1.1	Provide a protected environment or shelter.	0.4000
								1.2	Postpone the activity to a time window with better anticipated weather conditions.	1.0000
								4.3	Increase the remaining duration on the activity.	1.0000
								6.1	Pursue a project time extension for unreasonable delay beyond contractor's control.	0.8000
								9.1	Do nothing.	0.7200
41	Insufficient manpower	50	0.25	0	0.00	50	1	4.3	Increase the remaining duration on the activity.	0.9000
								9.1	Do nothing.	0.9000

Aggregated Problems

Activity Level Corrective Action No.	Description	Strength	Problem Number
6.1	Pursue a project time extension for unreasonable delay beyond contractor's control.	0.4439	11
4.3	Increase the remaining duration on the activity.	0.3776	11 41
1.2	Postpone the activity to a time window with better anticipated weather conditions.	0.1276	11
1.1	Provide a protected environment or shelter.	0.0510	11

Activity: G80200 INSTALL BLOCKING FOR WINDOWS Loc: MAIN
Trade responsible: GENERAL CONTRACTOR
Start date: 03FEB94
Projected(Actual) finish date: 08FEB94
Total duration: 4 days
Remaining duration: 0 days, 0%
Free float: 3 days
Total float: 60 days
Total float/remaining duration: Undefined(Divide By 0)

Activity Attributes	Degree of Applicability
10 Internal access	: 0.00
12 Labour intensive	: 1.00
14 Buffer activity	: 1.00
16 Design changes	: 0.00
17 High inspection	: 0.30
20 Low tolerance	: 0.50
21 Learning curve effects	: 0.50
22 Design complexity	: 0.50

Total number of days lost: 1.00
Total number of manhours lost: 0.00

Problem Source No.	Description	% total days lost	total days lost	% total whrs lost	total whrs lost	% occur	total occur	Activity Level Corrective Action No.	Description	Strength
44	Low skill level	100	1.00	100	0.00	100	2	2.3	Upgrade untrained personnel to trained personnel.	0.8000
								2.4	Discuss with subtrade foreman workforce performance.	1.0000
								2.9	Hire more experienced workers to lead inexperienced workers.	1.0000

Aggregated Problems

Activity Level Corrective Action No.	Description	Strength	Problem Number
2.4	Discuss with subtrade foreman workforce performance.	0.3571	44
2.9	Hire more experienced workers to lead inexperienced workers.	0.3571	44
2.3	Upgrade untrained personnel to trained personnel.	0.2857	44

Activity: G00200 INSTALL BLOCKING FOR WINDOWS Loc: 2
Trade responsible: GENERAL CONTRACTOR
Start date: 11FEB94
Projected(Actual) finish date: 15FEB94
Total duration: 3 days
Remaining duration: 0 days, 0%
Free float: 3 days
Total float: 57 days
Total float/remaining duration: Undefined(Divide By 0)

Activity Attributes	Degree of Applicability
10 Internal access	: 0.00
12 Labour intensive	: 1.00
14 Buffer activity	: 1.00
16 Design changes	: 0.00
17 High inspection	: 0.30
20 Low tolerance	: 0.50
21 Learning curve effects	: 0.50
22 Design complexity	: 0.50

Total number of days lost: 1.00
Total number of manhours lost: 8.00

Problem Source No.	Description	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Activity Level Corrective Action No.	Description	Strength
44	Low skill level	100	1.00	100	8.00	100	2	2.3	Upgrade untrained personnel to trained personnel.	0.0000
								2.4	Discuss with subtrade foreman workforce performance.	1.0000
								2.9	Hire more experienced workers to lead inexperienced workers.	1.0000

Aggregated Problems

Activity Level Corrective Action No.	Description	Strength	Problem Number
2.4	Discuss with subtrade foreman workforce performance.	0.3571	44
2.9	Hire more experienced workers to lead inexperienced workers.	0.3571	44
2.3	Upgrade untrained personnel to trained personnel.	0.2857	44

Activity: G00200 INSTALL BLOCKING FOR WINDOWS Loc: 3
Trade responsible: GENERAL CONTRACTOR
Start date: 18FEB94

Projected(Actual) finish date: 23FEB94
Total duration: 4 days
Remaining duration: 0 days, 0%
Free float: 4 days
Total float: 57 days
Total float/remaining duration: Undefined(Divide By 0)

Activity Attributes	Degree of Applicability
10 Internal access	: 0.00
12 Labour intensive	: 1.00
14 Buffer activity	: 1.00
16 Design changes	: 0.00
17 High inspection	: 0.30
20 Low tolerance	: 0.50
21 Learning curve effects	: 0.50
22 Design complexity	: 0.50

Total number of days lost: 2.20
Total number of manhours lost: 0.00

Problem Source No.	Description	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Activity Level Corrective Action No.	Description	Strength
41	Insufficient manpower	91	2.00		0.00	75	3	4.3	Increase the remaining duration on the activity.	1.0000
								9.1	Do nothing.	1.0000
56	Error in construction	9	0.20		0.00	25	1	5.10	Contact relevant parties for correction and/or information.	1.0000

Aggregated Problems

Activity Level Corrective Action No.	Description	Strength	Problem Number
4.3	Increase the remaining duration on the activity.	0.7500	41
5.10	Contact relevant parties for correction and/or information.	0.2500	56

Activity: G00200 INSTALL BLOCKING FOR WINDOWS Loc: 4
Trade responsible: GENERAL CONTRACTOR
Start date: 28FEB94
Projected(Actual) finish date: 02MAR94
Total duration: 3 days
Remaining duration: 0 days, 0%
Free float: 6 days
Total float: 54 days
Total float/remaining duration: Undefined(Divide By 0)

Activity Attributes	Degree of Applicability
10 Internal access	: 0.00
12 Labour intensive	: 1.00
14 Buffer activity	: 1.00
16 Design changes	: 0.00
17 High inspection	: 0.30
20 Low tolerance	: 0.50
21 Learning curve effects	: 0.50
22 Design complexity	: 0.50

Total number of days lost: 1.00

Total number of manhours lost: 0.00

Problem Source No.	Description	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Activity Level Corrective Action No.	Description	Strength
41	Insufficient manpower	100	1.00		0.00	100	1	4.3	Increase the remaining duration on the activity.	1.0000
								9.1	Do nothing.	1.0000

Aggregated Problems

Activity Level Corrective Action No.	Description	Strength	Problem Number
4.3	Increase the remaining duration on the activity.	0.5000	41
9.1	Do nothing.	0.5000	41

Activity: C00300 F/R/P/C/S HARD LANDSCAPING Loc: SITE
Trade responsible: GENERAL CONTRACTOR
Start date: 09FEB94
Projected(Actual) finish date: 08MAR94
Total duration: 20 days
Remaining duration: 2 days, 10%
Free float: 67 days
Total float: 67 days
Total float/remaining duration: 33.50

Activity Attributes	Degree of Applicability
1 High precipitation	: 1.00
3 High temperature	: 0.60
4 Low temperature	: 1.00
7 Ground conditions	: 1.00
8 Storage on site	: 1.00
9 Site congestion	: 1.00
11 External access	: 1.00
12 Labour intensive	: 0.00
14 Buffer activity	: 0.50
16 Design changes	: 1.00
18 Contract provision	: 0.50
21 Learning curve effects	: 0.20
22 Design complexity	: 1.00

Total number of days lost: 9.55
Total number of manhours lost: 88.00

Problem Source No.	Description	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Activity Level Corrective Action No.	Description	Strength
11	Too much precipitation	16	1.50	19	17.00	14	4	1.1	Provide a protected environment or shelter.	0.4000
								1.2	Postpone the activity to a time window with better anticipated weather conditions.	1.0000
								3.2	Where appropriate, use extra support or shoring to alleviate poor ground conditions.	1.0000
								4.3	Increase the remaining duration on the activity.	1.0000
								6.1	Pursue a project time extension for unreasonable delay beyond contractor's control.	0.5000
								9.1	Do nothing.	0.5000
31	Insuff./Incompl. Drawing	0	0.75	0	7.00	10	3	4.1	Postpone the activity.	1.0000

							4.2	Do secondary work on the activity.	0.2000
							4.3	Increase the remaining duration on the activity.	1.0000
							5.9	Improve architect/engineer/consultant coordination.	0.5000
							7.2	Issue a memo to the party concerned to request drawing completion.	1.0000
32 Drawing errors	3	0.25	5	4.00	3	1	2.6	When workers are idle, reroute manpower to other activities to prevent severe manpower loss.	1.0000
							4.10	Note down in daily report dates of information requested, conversations/verbal instructions, telephone calls etc..	1.0000
							5.14	Request information/clarification from architect and/or consultant(s) ASAP.	1.0000
34 Conflicting information	10	1.75	30	26.00	17	5	2.6	When workers are idle, reroute manpower to other activities to prevent severe manpower loss.	0.0000
							4.2	Do secondary work on the activity.	0.0000
							4.12	Monitor the activity closely.	1.0000
							5.9	Improve architect/engineer/consultant coordination.	1.0000
							5.10	Contact relevant parties for correction and/or information.	1.0000
41 Insufficient manpower	29	2.75	0	0.00	17	5	4.3	Increase the remaining duration on the activity.	0.0000
46 Low motivation/morale	5	0.50	9	0.00	7	2	1.3	Try to improve working conditions.	0.3000
							2.2	Reallocate manpower from preferably a buffer or non-critical activity (XXSSTT) to activity XXYYZZ..	0.5000
							2.5	If low motivation is exhibited by specific crew members, lay off unproductive workers and seek new ones.	0.7000
							2.6	When workers are idle, reroute manpower to other activities to prevent severe manpower loss.	0.5000
							4.1	Postpone the activity.	0.5000
56 Error in construction	11	1.05	23	20.00	20	0	2.2	Reallocate manpower from preferably a buffer or non-critical activity (XXSSTT) to activity XXYYZZ..	0.0000
							4.3	Increase the remaining duration on the activity.	0.5000
							4.21	Allocate time for rework to correct error.	0.0000
							5.10	Contact relevant parties for correction and/or information.	1.0000
							5.12	Notify owner/project manager about the possibility of delay if the activity affected is a critical one.	0.5000
							5.16	Issue speedy memo to affected parties.	0.5000
							5.17	Determine the impact of construction error on the project; if critical, seek additional trade/ workers for rework.	0.5000
							7.3	Open a delay claim.	0.5000
57 Layout error	10	1.00	7	6.00	3	1	4.14	Correct construction error at site immediately if possible.	0.6000
							4.15	Discuss with/notify subtrade(s) of required changes in layout.	1.0000
							5.14	Request information/clarification from architect and/or consultant(s) ASAP.	1.0000

Aggregated Problems

Activity No.	Level	Corrective Action Description	Strength	Problem Number
4.3		Increase the remaining duration on the activity.	0.2588	11 31 41 56
5.10		Contact relevant parties for correction and/or information.	0.0916	34 56

2.2	Reallocate manpower from preferably a buffer or non-critical activity (XXSSTT) to activity XXYYZZ.	0.0571	46 56
2.6	When workers are idle, reroute manpower to other activities to prevent severe manpower loss.	0.0553	32 34 46
5.9	Improve architect/engineer/consultant coordination.	0.0515	31 34
4.21	Allocate time for rework to correct error.	0.0433	56
4.1	Postpone the activity.	0.0418	31 46
4.12	Monitor the activity closely.	0.0375	34
4.2	Do secondary work on the activity.	0.0356	31 34
4.18	Note down in daily report dates of information requested, conversations/verbal instructions, telephone calls etc..	0.0354	32
1.2	Postpone the activity to a time window with better anticipated weather conditions.	0.0313	11
3.2	Where appropriate, use extra support or shoring to alleviate poor ground conditions.	0.0313	11
7.2	Issue a memo to the party concerned to request drawing completion.	0.0288	31
5.12	Notify owner/project manager about the possibility of delay if the activity affected is a critical one.	0.0270	56
5.16	Issue speedy memo to affected parties.	0.0270	56
5.17	Determine the impact of construction error on the project; if critical, seek additional trade/ workers for rework.	0.0270	56
7.3	Open a delay claim.	0.0270	56
5.14	Request information/clarification from architect and/or consultant(s) ASAP.	0.0240	32 57
2.5	If low motivation is exhibited by specific crew members, lay off unproductive workers and seek new ones.	0.0193	46
6.1	Pursue a project time extension for unreasonable delay beyond contractor's control.	0.0157	11
4.15	Discuss with/notify subtrade(s) of required changes in layout.	0.0133	57
1.1	Provide a protected environment or shelter.	0.0125	11
4.14	Correct construction error at site immediately if possible.	0.0080	57

File Used: D:\REP288\PROJ29\BENYUU

Report Date: 22DEC93
Report Time: 21:46:27
Revision Number: 0
Progress Date: 04MAR94

Date Window: From 04FEB94 to 10FEB94
Method used: max-min
Weighting condition: frequency of occurrence

Trade: 09 DRYWALL INC.
Total number of days lost: 4.00
Total number of manhours lost: 6.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
32	Drawing errors	0.200000	25	1.00	100	6.00	7	1		No corrective action - lack of supporting evidence	
41	Insufficient manpower	0.200000	13	0.50	0	0.00	14	2	1.1	Assign more men to the project.	0.0600
									1.3	Replace crew with a more experienced one.	1.0000
44	Low skill level	0.400000	19	0.75	0	0.00	43	6		No corrective action - lack of supporting evidence	
52	Rework (Workmanship)	0.200000	25	1.00	0	0.00	7	1		No corrective action - lack of supporting evidence	
57	Layout error	0.400000	19	0.75	0	0.00	29	4		No corrective action - lack of supporting evidence	

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
	Do nothing - lack of evidence.	1.0000	32 44 52 57

Trade: 12 BRICKERS ANONYMOUS
Total number of days lost: 2.25
Total number of manhours lost: 0.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
72	Poor ground conditions	1.000000	11	0.25		0.00	25	1		No corrective action - lack of supporting evidence	
95	Delay in award. contract	1.000000	89	2.00		0.00	75	3		No corrective action - lack of supporting evidence	

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
	Do nothing - lack of evidence.	1.0000	72 95

Trade: 15 HOLD AND COLD AIR & WATER
Total number of days lost: 5.25

Total number of manhours lost: 0.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
34	Conflicting information	0.250000	5	0.25		0.00	14	1	2.6	Improve subtrade coordination.	0.1000
									2.7	Improve architect/engineer/project manager coordination.	0.1000
									2.8	Open extra work order since problem originated with architect/engineer.	0.3000
41	Insufficient manpower	0.250000	19	1.00		0.00	29	2	1.1	Assign more men to the project.	0.0750
									1.3	Replace crew with a more experienced one.	0.5000
57	Layout error	0.500000	76	4.00		0.00	57	4		No corrective action - lack of supporting evidence	

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
	Do nothing - lack of evidence.	1.0000	57

Trade: 16 POWER INC.
Total number of days lost: 1.75
Total number of manhours lost: 10.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
31	Insuff./Incompl. Drawing	1.000000	86	1.50	100	10.00	75	3		No corrective action - lack of supporting evidence	
34	Conflicting information	0.500000	14	0.25	0	0.00	25	1	2.6	Improve subtrade coordination.	0.3000
									2.7	Improve architect/engineer/project manager coordination.	0.3500

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
	Do nothing - lack of evidence.	1.0000	31

Trade: G UBC CONSTRUCTION MANAGEMENT LAB
Total number of days lost: 12.30
Total number of manhours lost: 102.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
11	Too much precipitation	0.500000	53	6.50	61	111.00	36	12		No corrective action - lack of supporting evidence	
31	Insuff./Incompl. Drawing	0.166667	6	0.75	4	7.00	9	3		No corrective action - lack of supporting evidence	
32	Drawing errors	0.166667	2	0.25	2	4.00	3	1		No corrective action - lack of supporting evidence	
41	Insufficient manpower	0.500000	10	1.20	3	6.00	9	3	1.1	Assign more men to the project.	0.3500
									1.3	Replace crew with a more experienced one.	0.9333
									2.2	Discuss with subtrade its overall performance.	0.1333
									2.4	Prepare delay claim.	0.3000
44	Low skill level	0.500000	16	2.00	11	20.00	18	6		No corrective action - lack of supporting evidence	

46 Low motivation/morale	0.333333	0	0.00	4	8.00	6	2		No corrective action - lack of supporting evidence	
56 Error in construction	0.333333	5	0.60	11	20.00	15	5	1.3	Replace crew with a more experienced one.	0.9333
								1.4	Investigate alternate start of work day for crew.	0.1667
								1.5	Seek additional workmen for rework.	0.7500
								2.1	Adopt a more stringent quality control program for this trade.	0.2333
								2.2	Discuss with subtrade its overall performance.	0.5833
								2.5	Place special attention on activities for localized problem source.	0.5000
57 Layout error	0.166667	0	1.00	3	6.00	3	1		No corrective action - lack of supporting evidence	

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
	Do nothing - lack of evidence.	1.0000	11 31 32 44 46 57

File Used: D:\REP288\PROJ29\BENYUU

Report Date: 23DEC93
Report Time: 12:28:13
Revision Number: 0
Progress Date: 04MAR94

Date Window: From 07FEB94 to 18FEB94
Method used: max-min
Weighting condition: manhour_lost

Trade: 09 DRYWALL INC.
Total number of days lost: 4.00
Total number of manhours lost: 6.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
32	Drawing errors	0.200000	25	1.00	100	6.00	7	1		No corrective action - lack of supporting evidence	
41	Insufficient manpower	0.200000	13	0.50	0	0.00	14	2	1.1	Assign more men to the project.	0.0600
									1.3	Replace crew with a more experienced one.	1.0000
44	Low skill level	0.400000	19	0.75	0	0.00	43	6		No corrective action - lack of supporting evidence	
52	Rework (Workmanship)	0.200000	25	1.00	0	0.00	7	1		No corrective action - lack of supporting evidence	
57	Layout error	0.400000	19	0.75	0	0.00	29	4		No corrective action - lack of supporting evidence	

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
	Do nothing - lack of evidence.	1.0000	32

Trade: 12 BRICKERS ANONYMOUS
Total number of days lost: 2.25
Total number of manhours lost: 0.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
72	Poor ground conditions	1.000000	11	0.25		0.00	25	1		No corrective action - lack of supporting evidence	
95	Delay in award. contract	1.000000	89	2.00		0.00	75	3		No corrective action - lack of supporting evidence	

No manhour_lost for all problems of this trade

Trade: 15 HOLD AND COLD AIR & WATER
Total number of days lost: 5.25
Total number of manhours lost: 0.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
34	Conflicting information	0.250000	5	0.25		0.00	14	1	2.6	Improve subtrade coordination.	0.1000
									2.7	Improve architect/engineer/project manager coordination.	0.1000
									2.8	Open extra work order since problem originated with architect/engineer.	0.3000
41	Insufficient manpower	0.250000	19	1.00		0.00	29	2	1.1	Assign more men to the project.	0.0750
									1.3	Replace crew with a more experienced one.	0.5000
57	Layout error	0.500000	76	4.00		0.00	57	4		No corrective action - lack of supporting evidence	

No manhour_lost for all problems of this trade

Trade: 16 POWER INC.
Total number of days lost: 1.75
Total number of manhours lost: 10.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
31	Insuff./Incompl. Drawing	1.000000	86	1.50	100	10.00	75	3		No corrective action - lack of supporting evidence	
34	Conflicting information	0.500000	14	0.25	0	0.00	25	1	2.6	Improve subtrade coordination.	0.3000
									2.7	Improve architect/engineer/project manager coordination.	0.3500

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
	Do nothing - lack of evidence.	1.0000	31

Trade: G UBC CONSTRUCTION MANAGEMENT LAB
Total number of days lost: 12.30
Total number of manhours lost: 102.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
11	Too much precipitation	0.500000	53	6.50	61	111.00	36	12		No corrective action - lack of supporting evidence	
31	Insuff./Incompl. Drawing	0.166667	6	0.75	4	7.00	9	3		No corrective action - lack of supporting evidence	
32	Drawing errors	0.166667	2	0.25	2	4.00	3	1		No corrective action - lack of supporting evidence	
41	Insufficient manpower	0.500000	10	1.20	3	6.00	9	3	1.1	Assign more men to the project.	0.3500
									1.3	Replace crew with a more experienced one.	0.9333
									2.2	Discuss with subtrade its overall performance.	0.1333
									2.4	Prepare delay claim.	0.3000
44	Low skill level	0.500000	16	2.00	11	20.00	18	6		No corrective action - lack of supporting evidence	
46	Low motivation/morale	0.333333	0	0.00	4	8.00	6	2		No corrective action - lack of supporting evidence	
56	Error in construction	0.333333	5	0.60	11	20.00	15	5	1.3	Replace crew with a more experienced one.	0.9333
									1.4	Investigate alternate start of work day for crew.	0.1667
									1.5	Seek additional workmen for rework.	0.7500
									2.1	Adopt a more stringent quality control program for this trade.	0.2333
									2.2	Discuss with subtrade its overall performance.	0.5833

57 Layout error	0.166667	0	1.00	3	6.00	3	1	2.5 Place special attention on activities for localized problem source. No corrective action - lack of supporting evidence	0.5000

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
	Do nothing - lack of evidence.	1.0000	11 31 32 44 46 57

BENJAMIN YUE - EXTENDED EXAMPLE PROJECT

DAILY SITE TRADE ANALYSIS REPORT

File Used: D:\REP200\PROJ29\BENYUU

Report Date: 22DEC93
Report Time: 21:59:58
Revision Number: 0
Progress Date: 04MAR94

Date Window: From 04FEB94 to 18FEB94
Method used: max-min
Weighting condition: time_lost

Trade: 09 DRYWALL INC.
Total number of days lost: 4.00
Total number of manhours lost: 6.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
32	Drawing errors	0.200000	25	1.00	100	6.00	7	1		No corrective action - lack of supporting evidence	
41	Insufficient manpower	0.200000	13	0.50	0	0.00	14	2	1.1	Assign more men to the project.	0.0600
									1.3	Replace crew with a more experienced one.	1.0000
44	Low skill level	0.400000	19	0.75	0	0.00	43	6		No corrective action - lack of supporting evidence	
52	Rework (Workmanship)	0.200000	25	1.00	0	0.00	7	1		No corrective action - lack of supporting evidence	
57	Layout error	0.400000	19	0.75	0	0.00	29	4		No corrective action - lack of supporting evidence	

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
	Do nothing - lack of evidence.	1.0000	32 44 52 57

Trade: 12 BRICKERS ANONYMOUS
Total number of days lost: 2.25
Total number of manhours lost: 0.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
72	Poor ground conditions	1.000000	11	0.25		0.00	25	1		No corrective action - lack of supporting evidence	
95	Delay in award. contract	1.000000	89	2.00		0.00	75	3		No corrective action - lack of supporting evidence	

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
	Do nothing - lack of evidence.	1.0000	72 95

Trade: 15 HOLD AND COLD AIR & WATER
Total number of days lost: 5.25

Total number of manhours lost: 0.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
34	Conflicting information	0.250000	5	0.25		0.00	14	1	2.6	Improve subtrade coordination.	0.1000
									2.7	Improve architect/engineer/project manager coordination.	0.1000
									2.8	Open extra work order since problem originated with architect/engineer.	0.3000
41	Insufficient manpower	0.250000	19	1.00		0.00	29	2	1.1	Assign more men to the project.	0.0750
									1.3	Replace crew with a more experienced one.	0.5000
57	Layout error	0.500000	76	4.00		0.00	57	4		No corrective action - lack of supporting evidence	

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
	Do nothing - lack of evidence.	1.0000	57

Trade: 16 POWER INC.
Total number of days lost: 1.75
Total number of manhours lost: 10.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
31	Insuff./Incompl. Drawing	1.000000	86	1.50	100	10.00	75	3		No corrective action - lack of supporting evidence	
34	Conflicting information	0.500000	14	0.25	0	0.00	25	1	2.6	Improve subtrade coordination.	0.3000
									2.7	Improve architect/engineer/project manager coordination.	0.3500

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
	Do nothing - lack of evidence.	1.0000	31

Trade: G UBC CONSTRUCTION MANAGEMENT LAB
Total number of days lost: 12.30
Total number of manhours lost: 182.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
11	Too much precipitation	0.500000	53	6.50	61	111.00	36	12		No corrective action - lack of supporting evidence	
31	Insuff./Incompl. Drawing	0.166667	6	0.75	4	7.00	9	3		No corrective action - lack of supporting evidence	
32	Drawing errors	0.166667	2	0.25	2	4.00	3	1		No corrective action - lack of supporting evidence	
41	Insufficient manpower	0.500000	10	1.20	3	6.00	9	3	1.1	Assign more men to the project.	0.3500
									1.3	Replace crew with a more experienced one.	0.9333
									2.2	Discuss with subtrade its overall performance.	0.1333
									2.4	Prepare delay claim.	0.3000
44	Low skill level	0.500000	16	2.00	11	20.00	18	6		No corrective action - lack of supporting evidence	

46 Low motivation/morale	0.333333	0	0.00	4	0.00	6	2		No corrective action - lack of supporting evidence	
56 Error in construction	0.333333	5	0.60	11	20.00	15	5	1.3	Replace crew with a more experienced one.	0.9333
								1.4	Investigate alternate start of work day for crew.	0.1667
								1.5	Seek additional workmen for rework.	0.7500
								2.1	Adopt a more stringent quality control program for this trade.	0.2333
								2.2	Discuss with subtrade its overall performance.	0.5833
								2.5	Place special attention on activities for localized problem source.	0.5000
57 Layout error	0.166667	0	1.00	3	6.00	3	1		No corrective action - lack of supporting evidence	

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
	Do nothing - lack of evidence.	1.0000	11 31 32 44 57

BENJAMIN YUE - EXTENDED EXAMPLE PROJECT

DAILY SITE TRADE ANALYSIS REPORT

File Used: D:\REP200\PROJ29\BENYUU

Report Date: 22DEC93
Report Time: 21:15:59
Revision Number: 0
Progress Date: 04MAR94

Date Window: From 07FEB94 to 04MAR94
Method used: max-min
Weighting condition: frequency of occurrence

Trade: 09 DRYWALL INC.
Total number of days lost: 6.00
Total number of manhours lost: 6.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
32	Drawing errors	0.142857	17	1.00	100	6.00	5	1		No corrective action - lack of supporting evidence	
41	Insufficient manpower	0.428571	33	2.00	0	0.00	33	7	1.1	Assign more men to the project.	0.3000
									1.3	Replace crew with a more experienced one.	0.5000
									2.4	Prepare delay claim.	0.5000
44	Low skill level	0.285714	13	0.75	0	0.00	29	6		No corrective action - lack of supporting evidence	
52	Rework (Workmanship)	0.142857	17	1.00	0	0.00	5	1		No corrective action - lack of supporting evidence	
56	Error in construction	0.142857	0	0.50	0	0.00	10	2	1.3	Replace crew with a more experienced one.	0.5000
									1.5	Seek additional workmen for rework.	0.5000
									2.5	Place special attention on activities for localized problem source.	0.3000
57	Layout error	0.285714	13	0.75	0	0.00	19	4		No corrective action - lack of supporting evidence	

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
	Do nothing - lack of evidence.	1.0000	32 44 52 57

Trade: 12 BRICKERS ANONYMOUS
Total number of days lost: 3.75
Total number of manhours lost: 0.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
72	Poor ground conditions	1.000000	20	0.75		0.00	38	3		No corrective action - lack of supporting evidence	
95	Delay in award. contract	1.000000	80	3.00		0.00	63	5		No corrective action - lack of supporting evidence	

UBC CONSTRUCTION MANAGEMENT LAB

REPCON™

BENJAMIN YUE - EXTENDED EXAMPLE PROJECT

DAILY SITE TRADE ANALYSIS REPORT

File Used: B:\REPCON\PROJ29\BEN1DU

Report Date: 22DEC93
Report Time: 21:15:59
Revision Number: 0
Progress Date: 04MAR94

Date Window: From 07FEB94 to 04MAR94
Method used: max-min
Weighting condition: frequency of occurrence

Trade: 09 DRYWALL INC.
Total number of days lost: 6.00
Total number of manhours lost: 6.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
32	Drawing errors	0.142857	17	1.00	100	6.00	5	1		No corrective action - lack of supporting evidence	
41	Insufficient manpower	0.428571	33	2.00	0	0.00	33	7	1.1	Assign more men to the project.	0.3000
									1.3	Replace crew with a more experienced one.	0.5000
44	Low skill level	0.285714	13	0.75	0	0.00	29	6	2.4	Prepare delay claim.	0.5000
52	Rework (Workmanship)	0.142857	17	1.00	0	0.00	5	1		No corrective action - lack of supporting evidence	
56	Error in construction	0.142857	0	0.50	0	0.00	10	2		No corrective action - lack of supporting evidence	
									1.3	Replace crew with a more experienced one.	0.5000
									1.5	Seek additional workmen for rework.	0.5000
									2.5	Place special attention on activities for	0.3000
57	Layout error	0.285714	13	0.75	0	0.00	19	4		localized problem source.	
										No corrective action - lack of supporting evidence	

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
	Do nothing - lack of evidence.	1.0000	32 44 52 57

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
	Do nothing - lack of evidence.	1.0000	72 95

Trade: 15 HOLD AND COLD AIR & WATER
Total number of days lost: 8.50
Total number of manhours lost: 0.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
34	Conflicting information	0.142857	3	0.25		0.00	7	1	2.6	Improve subtrade coordination.	0.1000
									2.7	Improve architect/engineer/project manager coordination.	0.1000
									2.8	Open extra work order since problem originated with architect/engineer.	0.3000
41	Insufficient manpower	0.571429	50	4.33		0.00	64	9	1.1	Assign more men to the project.	0.4000
									1.3	Replace crew with a more experienced one.	0.5000
									2.4	Prepare delay claim.	0.5000
57	Layout error	0.285714	47	4.00		0.00	29	4		No corrective action - lack of supporting evidence	

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
2.4	Prepare delay claim.	0.6921	41
1.3	Replace crew with a more experienced one.	0.2857	41
2.8	Open extra work order since problem originated with architect/engineer.	0.0133	34
2.6	Improve subtrade coordination.	0.0044	34
2.7	Improve architect/engineer/project manager coordination.	0.0044	34

Trade: 16 POWER INC.
Total number of days lost: 4.00
Total number of manhours lost: 10.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
31	Insuff./Incompl. Drawing	0.500000	38	1.50	100	10.00	43	3		No corrective action - lack of supporting evidence	
34	Conflicting information	0.250000	6	0.25	0	0.00	14	1	2.6	Improve subtrade coordination.	0.1000
									2.7	Improve architect/engineer/project manager coordination.	0.1000
									2.8	Open extra work order since problem originated with architect/engineer.	0.3000
41	Insufficient manpower	0.250000	56	2.25	0	0.00	43	3	1.1	Assign more men to the project.	0.0750
									1.3	Replace crew with a more experienced one.	0.5000
									2.4	Prepare delay claim.	0.2000

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
	Do nothing - lack of evidence.	1.0000	31

Trade: G UBC CONSTRUCTION MANAGEMENT LAB
Total number of days lost: 21.90
Total number of manhours lost: 249.50

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
11	Too much precipitation	0.555556	31	6.75	51	127.00	24	15		No corrective action - lack of supporting evidence	
31	Insuff./Incompl. Drawing	0.111111	3	0.75	3	7.00	5	3		No corrective action - lack of supporting evidence	
32	Drawing errors	0.111111	1	0.25	2	4.00	2	1		No corrective action - lack of supporting evidence	
34	Conflicting information	0.111111	8	1.75	10	26.00	8	5	2.2	Discuss with subtrade its overall performance.	0.5000
									2.5	Place special attention on activities for localized problem source.	0.5000
									2.6	Improve subtrade coordination.	0.3000
									2.7	Improve architect/engineer/project manager coordination.	0.3000
									2.8	Open extra work order since problem originated with architect/engineer.	0.3000
41	Insufficient manpower	0.666667	32	7.00	2	6.00	23	14	1.1	Assign more men to the project.	0.4667
									1.3	Replace crew with a more experienced one.	0.9333
									2.2	Discuss with subtrade its overall performance.	0.5000
									2.4	Prepare delay claim.	0.5000
44	Low skill level	0.333333	9	2.00	8	20.00	10	6		No corrective action - lack of supporting evidence	
46	Low motivation/morale	0.222222	2	0.50	5	12.00	5	3		No corrective action - lack of supporting evidence	
56	Error in construction	0.444444	9	1.98	17	41.50	23	14	1.3	Replace crew with a more experienced one.	0.9333
									1.4	Investigate alternate start of work day for crew.	0.1111
									1.5	Seek additional workmen for rework.	0.9333
									2.1	Adopt a more stringent quality control program for this trade.	0.3111
									2.2	Discuss with subtrade its overall performance.	0.5000
									2.5	Place special attention on activities for localized problem source.	0.5000
57	Layout error	0.111111	5	1.00	2	6.00	2	1		No corrective action - lack of supporting evidence	

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
2.2	Discuss with subtrade its overall performance.	0.7411	34 41 56
1.3	Replace crew with a more experienced one.	0.1958	41 56
2.5	Place special attention on activities for localized problem source.	0.0395	34 56
2.1	Adopt a more stringent quality control program for this trade.	0.0213	56
2.6	Improve subtrade coordination.	0.0032	34

BENJAMIN YUE - EXTENDED EXAMPLE PROJECT

DAILY SITE TRADE ANALYSIS REPORT

File Used: D:\REP200\PROJ29\BENYUU

Report Date: 23DEC93
Report Time: 12:17:50
Revision Number: 0
Progress Date: 04MAR94

Date Window: from 07FEB94 to 04MAR94
Method used: max-min
Weighting condition: manhour_lost

Trade: 09 DRYWALL INC.
Total number of days lost: 6.00
Total number of manhours lost: 6.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
32	Drawing errors	0.142857	17	1.00	100	6.00	5	1		No corrective action - lack of supporting evidence	
41	Insufficient manpower	0.428571	33	2.00	0	0.00	33	7	1.1	Assign more men to the project.	0.3000
									1.3	Replace crew with a more experienced one.	0.5000
									2.4	Prepare delay claim.	0.5000
44	Low skill level	0.285714	13	0.75	0	0.00	29	6		No corrective action - lack of supporting evidence	
52	Rework (Workmanship)	0.142857	17	1.00	0	0.00	5	1		No corrective action - lack of supporting evidence	
56	Error in construction	0.142857	8	0.50	0	0.00	10	2	1.3	Replace crew with a more experienced one.	0.5000
									1.5	Seek additional workmen for rework.	0.5000
									2.5	Place special attention on activities for localized problem source.	0.3000
57	Layout error	0.285714	13	0.75	0	0.00	19	4		No corrective action - lack of supporting evidence	

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
	Do nothing - lack of evidence.	1.0000	32

Trade: 12 BRICKERS ANONYMOUS
Total number of days lost: 3.75
Total number of manhours lost: 0.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
72	Poor ground conditions	1.000000	20	0.75		0.00	38	3		No corrective action - lack of supporting evidence	
95	Delay in award. contract	1.000000	80	3.00		0.00	63	5		No corrective action - lack of supporting evidence	

No manhour_lost for all problems of this trade

Trade: 15 HOLD AND COLD AIR & WATER
Total number of days lost: 0.50

Total number of manhours lost: 0.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade No.	Level	Corrective Action Description	Strength
34	Conflicting information	0.142857	3	0.25		0.00	7	1	2.6		Improve subtrade coordination.	0.1000
									2.7		Improve architect/engineer/project manager coordination.	0.1000
									2.8		Open extra work order since problem originated with architect/engineer.	0.3000
41	Insufficient manpower	0.571429	58	4.33		0.00	64	9	1.1		Assign more men to the project.	0.4000
									1.3		Replace crew with a more experienced one.	0.5000
57	Layout error	0.285714	47	4.00		0.00	29	4	2.4		Prepare delay claim.	0.5000
											No corrective action - lack of supporting evidence	

No manhour_lost for all problems of this trade

Trade: 16 POWER INC.
Total number of days lost: 4.00
Total number of manhours lost: 10.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade No.	Level	Corrective Action Description	Strength
31	Insuff./Incompl. Drawing	0.500000	38	1.50	100	10.00	43	3			No corrective action - lack of supporting evidence	
34	Conflicting information	0.250000	6	0.25	0	0.00	14	1	2.6		Improve subtrade coordination.	0.1000
									2.7		Improve architect/engineer/project manager coordination.	0.1000
									2.8		Open extra work order since problem originated with architect/engineer.	0.3000
41	Insufficient manpower	0.250000	56	2.25	0	0.00	43	3	1.1		Assign more men to the project.	0.0750
									1.3		Replace crew with a more experienced one.	0.5000
									2.4		Prepare delay claim.	0.2000

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
	Do nothing - lack of evidence.	1.0000	31

Trade: G UBC CONSTRUCTION MANAGEMENT LAB
Total number of days lost: 21.90
Total number of manhours lost: 249.50

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade No.	Level	Corrective Action Description	Strength
11	Too much precipitation	0.555556	31	6.75	51	127.00	24	15			No corrective action - lack of supporting evidence	
31	Insuff./Incompl. Drawing	0.111111	3	0.75	3	7.00	5	3			No corrective action - lack of supporting evidence	
32	Drawing errors	0.111111	1	0.25	2	4.00	2	1			No corrective action - lack of supporting evidence	
34	Conflicting information	0.111111	8	1.75	10	26.00	8	5	2.2		Discuss with subtrade its overall performance.	0.5000
									2.5		Place special attention on activities for localized problem source.	0.5000
									2.6		Improve subtrade coordination.	0.3000

								2.7	Improve architect/engineer/project manager coordination.	0.3000
								2.8	Open extra work order since problem originated with architect/engineer.	0.3000
41 Insufficient manpower	0.666667	32	7.00	2	6.00	23	14	1.1	Assign more men to the project.	0.4667
								1.3	Replace crew with a more experienced one.	0.9333
								2.2	Discuss with subtrade its overall performance.	0.5000
								2.4	Prepare delay claim.	0.5000
44 Low skill level	0.333333	9	2.00	8	20.00	10	6		No corrective action - lack of supporting evidence	
46 Low motivation/morale	0.222222	2	0.50	5	12.00	5	3		No corrective action - lack of supporting evidence	
56 Error in construction	0.444444	9	1.90	17	41.50	23	14	1.3	Replace crew with a more experienced one.	0.9333
								1.4	Investigate alternate start of work day for crew.	0.1111
								1.5	Seek additional workmen for rework.	0.9333
								2.1	Adopt a more stringent quality control program for this trade.	0.3111
								2.2	Discuss with subtrade its overall performance.	0.5000
								2.5	Place special attention on activities for localized problem source.	0.5000
57 Layout error	0.111111	5	1.00	2	6.00	2	1		No corrective action - lack of supporting evidence	

Aggregated Problems

Trade Level Corrective Action No. Description	Strength	Problem Number
Do nothing - lack of evidence.	1.0000	11 31 32 44 46 57

BENJAMIN YUE - EXTENDED EXAMPLE PROJECT

DAILY SITE TRADE ANALYSIS REPORT

File Used: D:\REP288\PROJ29\BENYUU

Report Date: 22DEC93
Report Time: 21:28:57
Revision Number: 0
Progress Date: 04MAR94

Date Window: From 07FEB94 to 04MAR94
Method used: max-min
Weighting condition: time_lost

Trade: 09 DRYWALL INC.
Total number of days lost: 6.00
Total number of manhours lost: 6.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
32	Drawing errors	0.142857	17	1.00	100	6.00	5	1		No corrective action - lack of supporting evidence	
41	Insufficient manpower	0.428571	33	2.00	0	0.00	33	7	1.1	Assign more men to the project.	0.3000
									1.3	Replace crew with a more experienced one.	0.5000
									2.4	Prepare delay claim.	0.5000
44	Low skill level	0.285714	13	0.75	0	0.00	29	6		No corrective action - lack of supporting evidence	
52	Rework (Workmanship)	0.142857	17	1.00	0	0.00	5	1		No corrective action - lack of supporting evidence	
56	Error in construction	0.142857	0	0.50	0	0.00	10	2	1.3	Replace crew with a more experienced one.	0.5000
									1.5	Seek additional workmen for rework.	0.5000
									2.5	Place special attention on activities for localized problem source.	0.3000
57	Layout error	0.285714	13	0.75	0	0.00	19	4		No corrective action - lack of supporting evidence	

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
	Do nothing - lack of evidence.	1.0000	32 44 52 57

Trade: 12 BRICKERS ANONYMOUS
Total number of days lost: 3.75
Total number of manhours lost: 0.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
72	Poor ground conditions	1.000000	20	0.75		0.00	38	3		No corrective action - lack of supporting evidence	
95	Delay in award. contract	1.000000	80	3.00		0.00	63	5		No corrective action - lack of supporting evidence	

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
	Do nothing - lack of evidence.	1.0000	72 95

Trade: 15 HOLD AND COLD AIR & WATER
Total number of days lost: 8.50
Total number of manhours lost: 0.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
34	Conflicting information	0.142857	3	0.25		0.00	7	1	2.6	Improve subtrade coordination.	0.1000
									2.7	Improve architect/engineer/project manager coordination.	0.1000
									2.8	Open extra work order since problem originated with architect/engineer.	0.3000
41	Insufficient manpower	0.571429	50	4.33		0.00	64	9	1.1	Assign more men to the project.	0.4000
									1.3	Replace crew with a more experienced one.	0.5000
									2.4	Prepare delay claim.	0.5000
57	Layout error	0.285714	47	4.00		0.00	29	4		No corrective action - lack of supporting evidence	

Aggregated Problems

Trade Level Corrective Action No.	Description	Strength	Problem Number
2.4	Prepare delay claim.	0.7483	41
1.3	Replace crew with a more experienced one.	0.2419	41
2.8	Open extra work order since problem originated with architect/engineer.	0.0059	34
2.6	Improve subtrade coordination.	0.0020	34
2.7	Improve architect/engineer/project manager coordination.	0.0020	34

Trade: 16 POWER INC.
Total number of days lost: 4.00
Total number of manhours lost: 10.00

Problem Source No.	Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
31	Insuff./Incompl. Drawing	0.500000	38	1.50	100	10.00	43	3		No corrective action - lack of supporting evidence	
34	Conflicting information	0.250000	6	0.25	0	0.00	14	1	2.6	Improve subtrade coordination.	0.1000
									2.7	Improve architect/engineer/project manager coordination.	0.1000
									2.8	Open extra work order since problem originated with architect/engineer.	0.3000
41	Insufficient manpower	0.250000	56	2.25	0	0.00	43	3	1.1	Assign more men to the project.	0.0750
									1.3	Replace crew with a more experienced one.	0.5000
									2.4	Prepare delay claim.	0.2000

Aggregated Problems

Trade Level Corrective Action No. Description	Strength	Problem Number
Do nothing - lack of evidence.	1.0000	31

Trade: G UBC CONSTRUCTION MANAGEMENT LAB
Total number of days lost: 21.90
Total number of manhours lost: 249.50

Problem Source No. Description	Dispersion Index	% total days lost	total days lost	% total mhrs lost	total mhrs lost	% occur	total occur	Trade Level Corrective Action No.	Description	Strength
11 Too much precipitation	0.555556	31	6.75	51	127.00	24	15		No corrective action - lack of supporting evidence	
31 Insuff./Incompl. Drawing	0.111111	3	0.75	3	7.00	5	3		No corrective action - lack of supporting evidence	
32 Drawing errors	0.111111	1	0.25	2	4.00	2	1		No corrective action - lack of supporting evidence	
34 Conflicting information	0.111111	8	1.75	10	26.00	8	5	2.2	Discuss with subtrade its overall performance.	0.5000
								2.5	Place special attention on activities for localized problem source.	0.5000
								2.6	Improve subtrade coordination.	0.3000
								2.7	Improve architect/engineer/project manager coordination.	0.3000
								2.8	Open extra work order since problem originated with architect/engineer.	0.3000
41 Insufficient manpower	0.666667	32	7.00	2	6.00	23	14	1.1	Assign more men the project.	0.4667
								1.3	Replace crew with a more experienced one.	0.9333
								2.2	Discuss with subtrade its overall performance.	0.5000
								2.4	Prepare delay claim.	0.5000
44 Low skill level	0.333333	9	2.00	8	20.00	10	6		No corrective action - lack of supporting evidence	
46 Low motivation/morale	0.222222	2	0.50	5	12.00	5	3		No corrective action - lack of supporting evidence	
56 Error in construction	0.444444	9	1.90	17	41.50	23	14	1.3	Replace crew with a more experienced one.	0.9333
								1.4	Investigate alternate start of work day for crew.	0.1111
								1.5	Seek additional workmen for rework.	0.9333
								2.1	Adopt a more stringent quality control program for this trade.	0.3111
								2.2	Discuss with subtrade its overall performance.	0.5000
								2.5	Place special attention on activities for localized problem source.	0.5000
57 Layout error	0.111111	5	1.00	2	6.00	2	1		No corrective action - lack of supporting evidence	

Aggregated Problems

Trade Level Corrective Action No. Description	Strength	Problem Number
Do nothing - lack of evidence.	1.0000	11 31 32 44 46 57