A STUDY ON THE OPTIMAZATION OF CONSTRUCTION MANAGEMENT BY USING A DESIGN STRUCTURE MATRIX

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ABSTRACT: In the construction industry, complex works are carried out with significant resources under non-linear circumstances where clear concepts of project management could be of benefit to all parties and personnel involved. In this paper, we define the optimum project management configuration for construction management by using DSM (Design Structure Matrix). Furthermore DSM can be visualized as a network model, and then Graph Theory provides us the numerical results.

Keywords: Design Structure Matrix, Optimal PM, Graph Theory, Scope & Communication Management

1. INTRODUCTION

Each construction contract is unique in nature and of fixed-term duration and is therefore commonly defined as "A Project". The project management (PM) concept, comprising several elements, should be adopted for controlling and managing a complicated project within the required budget and programme constraints to ensure product quality. The combination and/or configuration of many PM elements should be optimized depending on the business field and the actual conditions faced. In the early 1990s the PM concept had been established and introduced by many organizations, such as the Project Management Institute (USA) [1] and the Association for Project Management (UK) [2], which have now attained worldwide acceptance. During our research, we carried out a general survey regarding PM knowledge areas and analyzed the results using DSM to identify the optimum management process. To determine the optimal construction management configuration, we used graph theory and the assumption that the interdependent management elements have a network structure.

2. LATEST PM DEVELOPMENT

In the 1980s, Total Quality Management (TQM) was introduced to construction PM practices as an evolution of the process adopted in the manufacturing industries. From that time, most management organizations had established the Quality + Cost + Duration (QCD) Triangle Management Concept (**Figure 1**), which is commonly referred to as the "Eternal Triangle [3]" in Europe and the USA. This QCD-Triangle is also known as the 1st Generation PM.

In 1996 USA, non-profit making organization PMI published "A Guide to the Project Management Body of Knowledge (called "PMBOK")", which introduced 6 more management elements as presented in **Table 1**. PMI's management structure is referred to as the 2nd Generation PM or Modern PM. According to PMBOK, no hierarchy is assigned to the 9 knowledge areas, however the role of Project Integration Management, based on PMBOK, should be the optimization of the other 8 elements which themselves are complexly co-related, interacted, and interdependent as illustrated in **Figure 2**.

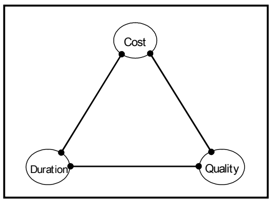


Figure 1. QCD-Triangle

Table 1. Management Elements by PMI

Project Management Knowledge Areas proposed by PMI		
Project Integration Management	Project Scope Management	Project Time Management
Project Cost Management	Project Quality Management	Human Resource Management
Project Communication Management	Project Risk Management	Project Procurement Management

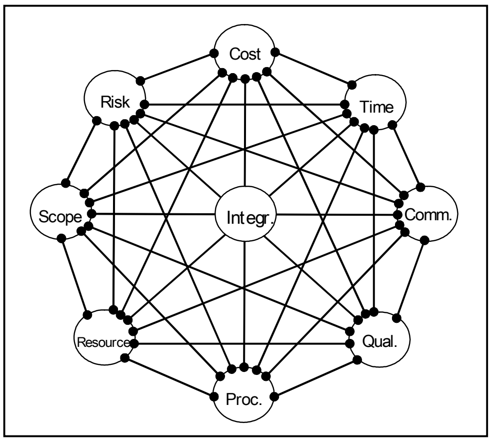


Figure 2. Complicated Relationship

In 2001 Japan, the 3rd Generation PM, called P2M (Project and Programme Management for Enterprise Innovation) was proposed to the world. The basic concept of P2M is the development of capable project managers who are able to perform in complex social circumstances. P2M consists of a total of 24 management areas as shown in **Figure 3**.

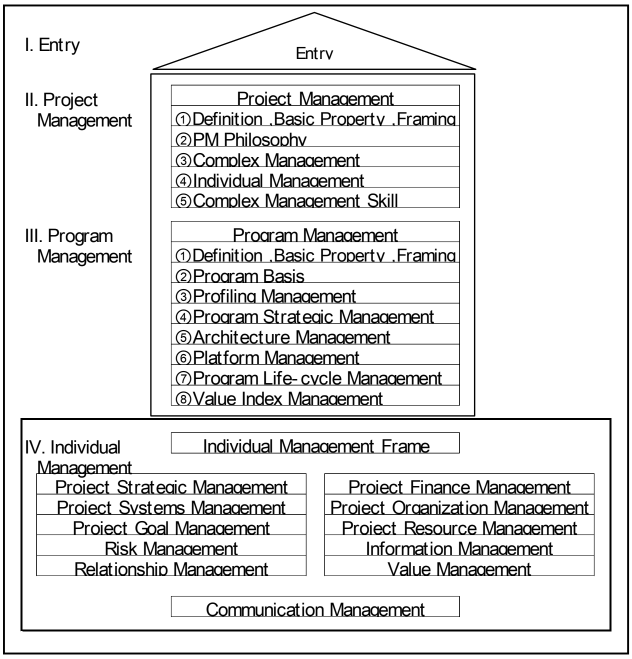


Figure 3. P2M Management "Tower" [4]

The total life cycle time (TLCT) of social infrastructure projects can be extremely long, such as the Tunnel between Hokkaido and Honshu (Japan), and the Channel Tunnel between UK and France. The physical construction period is however only a fraction of the TLCT and may involve a large number of civil engineers, site workers, construction equipment and materials that result in impacts on the whole project [5].

Due to increased complexity, environmental constraints and other restrictions on construction sites since the 1980s, PM elements and considerations must be adjusted; however the combination of management elements will not be the same for all types of Projects. In this paper we introduce the optimum method for PM configuration, and identify "the core management elements" supporting the Eternal QCD PM.

3. RESEARCH ON THE STATE

A construction project is usually undertaken by 3 parties, namely: the client, consultant and contractor. As clients of civil engineering projects are frequently government authorities, we have targeted our research to the PM of the consultant and contractor.

3.1 The Subject of PM Elements

PMI has over 100,000 members in whole of the world, which means that PMBOK is widely accepted in many fields. In this paper we survey the balancing of management elements based on PMBOK, though Project Integration Management was excluded as this is a function of the other 8 elements as previously described.

3.2 Construction Phase

As we mentioned above, there are many project phases to be managed during the project life cycle time. We believe that the importance of PM during the construction phase is most significant because field works impact on public safety and the environment. We therefore focused on the differences in emphasis of PM approaches adopted between contractor and consultant, and between Japanese domestic organizations and overseas. After describing our survey methodology below, we analyze the optimum PM for the Construction Phase.

3.3 Management Matrix

We adopted the 8 x 8 square binary matrix as a Management Matrix which has advantages for analyzing the complicated interdependencies between the 8 management elements defined by PMBOK.

Table 2. Management Matrix

Direction of affection ↓

		①	②	③	④	⑤	⑥	⑦	⑧
Cost	①	■							
Time	②		■		★				
Communication	③			■					
Quality	④				■				
Procurement	⑤					■			
Resource	⑥						■		
Scope	⑦							■	
Risk	⑧								■

For example, if Time is affected by Quality, the cell (Row 2 x Column 4) shall be marked 1 (star marked). In the same manner, all 56 cells are considered and evaluated. Due to the direction of affection, this matrix should not be symmetric.

3.4 Surveys by Management Matrix

We utilized a management matrix format for surveying the relationship of management elements for Japanese domestic contractors and consultants and managers working overseas.

As it is impractical to call all managers to testifying, we conducted the survey by issuing the Matrix by e-mail for completion and return.

We received a total of 111 replies, which comprised domestically 42 from contractors, 39 from consultants, and 31 from overseas (Hong Kong, Vietnam, Philippine, Taiwan, UK, USA).

4. ANALYSIS BY USING A DSM

To analyze the survey results we used a "Design Structure Matrix" (DSM), which has been widely studied by the Massachusetts Institute Technology (MIT) since the 1990s, and was originally introduced by Warfield in the 1970s, and Steward in the 1980s.

There are several widely accepted PM tools, such as the Program Evaluation and Review Technique (PERT), Gantt chart, and Critical Path Method; however they do not take rework and/or iteration into consideration. Other PM tools facilitate the breaking down of the complex system into elements, but reintegration is extremely difficult.

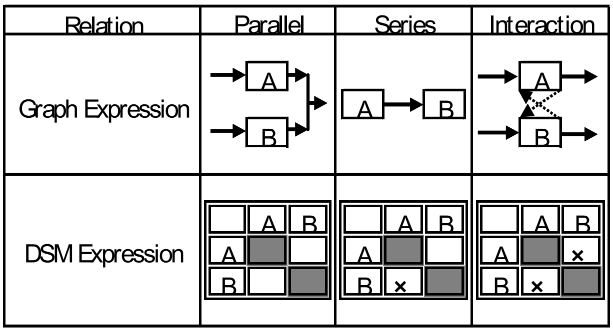
DSM is known as "The Dependency Structure Matrix", "The Problem Solving Matrix" or "The Design Precedence Matrix", and has been widely adopted by many industries, including: Jet Engine Design and Car Manufacturing [6] [7] [8].

4.1 Outline of DSM

The system processes are shown by Columns and Rows in the DSM and interrelationships marked in each cell in a similar manner to the Management Matrix utilized for surveying.

The relationship between 2 elements is shown in **Table 3** below, where it should be noted that a mark placed above the diagonal line represents non efficient rework or iteration in the system.

Table 3. DSM Indication and 2 Elements Relationship



4.2 Partitioning Algorism for Optimization [9]

The purpose of partitioning is that the possibility of rework or iteration is minimized by the replacement of task processes on the columns and cells of the DSM. The target of partitioning is to place marked cells above the diagonal line either below the line, or as close to the line as possible. As a result rework loops are either eliminated or become negligible, which means that loop involved tasks are minimized and the potential efficiency of the system maximized as a result.

4.3 Tearing Algorism for Optimization [9]

The other optimization algorism of DSM is Tearing. For the removal of marked cells above a diagonal line, an assumption such as that affecting information to be controlled can be considered, and then the best commencement task allocated. As no theoretical rules for tearing have been established, we just need to ensure that the number of tearing cells should be as small as possible, and/or any large rework loop is reduced to several small loops.

4.4 Survey Results by Management Matrix

The survey results for each cell were summed up and the average and median calculated with a threshold between 0 and 1. As the average and median results were very close, we used the average results giving the management matrixes for contractor's, consultant's, and 'overseas' presented in **Tables 4-6** below.

Table 4. Management Matrix for Contractor

		①	②	③	④	⑤	⑥	⑦	⑧	in	link
Cost	①		1	0	1	1	1	0	1	5	10
Time	②	1		0	1	1	1	0	0	4	8
Communication	③	0	0		0	1	0	0	1	2	5
Quality	④	1	1	0		1	1	0	0	4	8
Procurement	⑤	1	1	1	0		0	0	0	3	7
Resource	⑥	1	1	1	1	0		1	0	5	9
Scope	⑦	0	0	0	0	0	0		0	0	1
Risk	⑧	1	0	1	1	0	1	0		4	6
	out	5	4	3	4	4	4	1	2		54

Table 5. Management Matrix for Consultant

		①	②	③	④	⑤	⑥	⑦	⑧	in	link
Cost	①		1	0	1	1	1	1	1	6	12
Time	②	1		0	1	1	1	1	1	6	11
Communication	③	0	0		0	0	1	0	0	1	3
Quality	④	1	1	1		0	1	0	0	4	8
Procurement	⑤	1	1	0	0		0	0	0	2	4
Resource	⑥	1	0	0	1	0		0	0	2	6
Scope	⑦	1	1	0	0	0	0		0	2	4
Risk	⑧	1	1	1	1	0	0	0		4	6
	out	6	5	2	4	2	4	2	2		54

Table 6. Management Matrix for 'Overseas'

		①	②	③	④	⑤	⑥	⑦	⑧	in	link
Cost	①		1	1	1	1	1	0	1	6	12
Time	②	1		1	1	1	1	1	0	6	10
Communication	③	1	0		0	0	1	0	0	2	6
Quality	④	1	1	0		1	1	0	0	4	6
Procurement	⑤	1	1	1	0		0	1	0	4	7
Resource	⑥	1	0	1	0	0		1	0	3	7
Scope	⑦	0	0	0	0	0	0		0	0	3
Risk	⑧	1	1	0	0	0	0	0		2	3
	out	6	4	4	2	3	4	3	1		54

4.5 Radar Chart Analysis

The results from these tables are plotted in the radar chart below, which shows the management elements for each business field where the maximum relation is 1, and others are pro-rata.

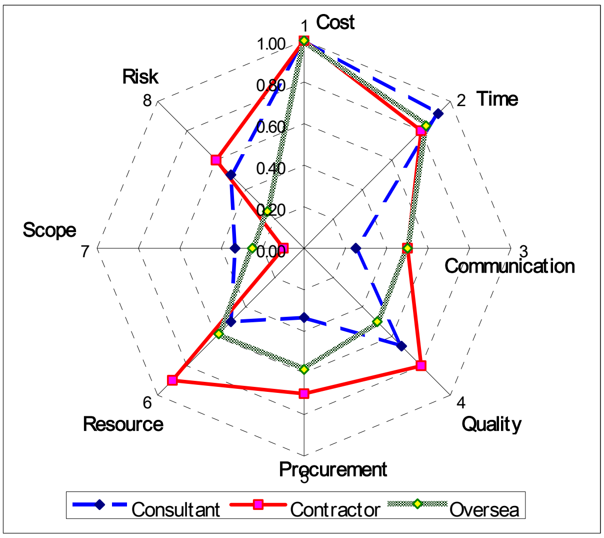


Figure 4. Rader Chart Comparison of Management Matrix

There are several conclusions that can be drawn from this chart. Firstly, Communication for contractor's and 'overseas' is higher showing clearly that these business fields place great importance on this management factor which in practice requires the exchange information between client, public adjacent to the project, police, fire service, etc.

Secondly, Procurement for contractor's and 'overseas' is also higher showing budgeting is controlled by purchasing of materials and supporting contractors.

Thirdly, Resource for domestic contractors is especially high reflecting the culture in Japan where experience and knowledge is considered to belong to the individual and not to the organization.

Finally, Risk for the 'overseas' business field is far below that of the domestic construction organization. We believe this may be due to differences in the contract conditions and business customs within these construction environments.

4.6 Management Process Analysis by DSM

After partitioning and tearing is applied to optimize the contractor's management matrix, the resultant 'optimal' management matrix is presented in **Table 7**. Similarly, **Tables 8 & 9** show the 'optimal' management matrixes for consultants and 'overseas' , though no tearing could be applied.

Table 7. Optimal PM Process for Contractor

		⑦	③	⑤	⑥	②	①	④	⑧
Scope	⑦	1							
Communication	③		2	1					~~1~~
Procurement	⑤	1		3		1	1		
Resource	⑥	1	1		4	1	1	1	
Time	②			1	1	5	1	1	
Cost	①			1	1	1	6	1	1
Quality	④			1	1	1	1	7	
Risk	⑧	1			1		1	1	8

Table 8. Optimal PM Process for Consultant

		③	⑦	⑤	⑥	②	①	④	⑧
Communication	③	1			1				
Scope	⑦		2			1	1		
Procurement	⑤			3		1	1		
Resource	⑥				4		1	1	
Time	②		1	1	1	5	1	1	1
Cost	①		1	1	1	1	6	1	1
Quality	④	1		1		1	1	7	
Risk	⑧	1				1	1	1	8

Table 9. Optimal PM Process for 'Overseas'

		⑦	③	⑥	⑤	①	②	④	⑧
Scope	⑦	1							
Communication	③		2	1		1			
Resource	⑥	1	1	3		1			
Procurement	⑤	1	1		4	1	1		
Cost	①		1	1	1	5	1	1	1
Time	②	1	1	1	1	1	6	1	
Quality	④			1	1	1	1	7	
Risk	⑧					1	1		8

The major findings from the above tables are a.) differences in the management processes between contractor and consultant, and b.) tight management combination of QCD.

The first finding is that scope management is not a contractors concern, however consultants needs to take care of budget, duration, quality and other factors on behalf of the client. Before evaluating the feasibility of a project, consultants need to obtain considerable information and exchange it with relevant organizations to ensure proper action is taken. It is clear that the management matrix approach, proposed by the authors, can predict actual management situations and provide the focus for problem mitigation.

5. VISUALIZING A MANAGEMENT MATRIX

5.1 Visualization by Management Network System

In this section, we visualize the PM for construction as a management network system for quantifying the importance of each management element.

The management network defines each element as a node (N=8) and the relationship between nodes as a link. Each link has an affection direction, so that the network is a directional graph. On this basis, **Table 7** (the 'optimal' PM for contractor) can be visualized as **Figure 5** below. When compared to Figure 2, this shows a clear prejudiced view, or bias, which would be different in each of the business fields and even within the same field from time to time.

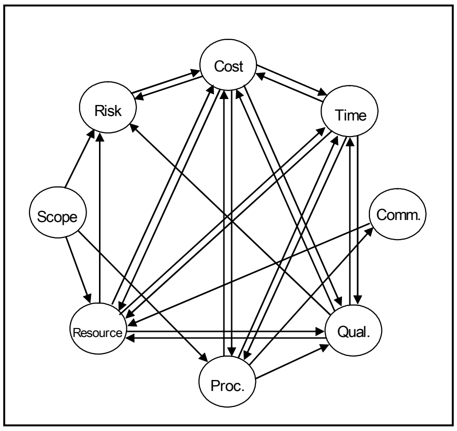


Figure 5. Optimal PM for Contractor (Visualized)

5.2 Characteristic Analysis by Graph Theory

The complicated management system is described as a relationship graph, and we can analyze it by utilizing graph theory to quantify the character of each management element. There are many important formulae used for graph theory, the key ones we have adopted are [10] [11]:

a) In-degree is the number of links towards node i . This index shows the extent of affection and information concentration.

$$In\text{-}degree\ \ (i) = \frac{1}{N-1}\sum_{j=1}^{N} x_{ji} \qquad (1)$$

x_{ji} is the number of links from node j to node i .

b) Out-degree is the number of link from the node.

$$Out\text{-}degree\ \ (i) = \frac{1}{N-1}\sum_{j=1}^{N} x_{ij} \qquad (2)$$

x_{ij} is the number of links from node i to node j .

c) Closeness shows the approach-ness of node i in the network system. It is not the physical distance, but the reciprocal of the shortest step.

$$Closeness\ \ (i) = \frac{N-1}{\sum_{j=1}^{N} \delta_{ij}} \qquad (3)$$

δ_{ij} is the shortest distance (step) from node i to node j.

d) Between-ness shows the brokerage of transmitting information in the network.

$$Between\text{-}ness\ \ (i) = \sum_{j=1,k=1}^{N} \frac{Gpaths_{j \to i \to k}}{Gpaths_{j \to k}} \qquad (4)$$

$Gpaths_{j \to k}$ is all possible shortest steps from node j to node k,

$Gpaths_{j \to i \to k}$ is the shortest steps from node j to node i passing through node k.

Using the above formulae we calculated the network characteristics as follows:

Table 10. Management Network Characteristic

Node (i)		In-degree		Out-degree		Closeness		Between-ness	
		after partitioning	after tearing	after partitioning	after tearing	after partitioning	after tearing	after partitioning	after tearing
①	Cost	0.714	0.714	0.714	0.714	0.778	0.778	6.083	8.583
②	Time	0.571	0.571	0.571	0.571	0.700	0.700	1.750	2.750
③	Comm.	0.143	0.143	0.286	0.143	0.583	0.438	0.750	0.250
④	Qual.	0.571	0.571	0.571	0.571	0.700	0.700	1.083	1.083
⑤	Proc.	0.571	0.571	0.429	0.429	0.583	0.583	3.333	7.333
⑥	Resource	0.571	0.571	0.714	0.714	0.778	0.778	6.667	6.667
⑦	Scope	0.429	0.429	0.000	0.000	0.000	0.000	0.000	0.000
⑧	Risk	0.286	0.143	0.571	0.571	0.700	0.700	0.333	0.333

We have taken the QCD Triangle Between-ness as the 3-dimensional vector space and define the QCD Between-ness Vector $|P|$ as below.

$$|P| = \sqrt{Q^2 + C^2 + C^2} \qquad (5)$$

- after Partitioning $\quad |P|_P = 6.422$
- after Tearing $\quad |P|_T = 9.078$

Based on graph theory, the partitioning & tearing efficiency is further examined.

6. SIMULATION FOR OPTIMAL PM

After partitioning and tearing of the contractors management matrix, we found the optimized PM elements configuration. As we believe that there must be some tolerance or allowable range for combination to determine the theoretical best configuration of management elements, we utilized the contractor's management matrix (after partitioning and tearing was applied) as the Simulation Matrix for investigating the optimal management range.

6.1 QCD Efficiency Simulation by Graph Theory

Table 11 is the simulation matrix determined for improving QCD efficiency. Even if the cells below the diagonal line, and 2 more cells just above it are marked 1, the management process by DSM algorisms would not alter. As there are 14 blank cells that could be filled, the total possible combinations for increasing additional link C is:

$$C = 2^{14} = 16{,}384$$

Table 11. Simulation Matrix for Contractor

		⑦	③	⑤	⑥	②	①	④	⑧
Scope	⑦	1							
Communication	③	×	2	1					
Procurement	⑤	1	×	3	×	1	1		
Resource	⑥	1	1	×	4	1	1	1	
Time	②	D_1	D_2	1	1	5	1	1	
Cost	①	C_1	C_2	1	1	1	6	1	1
Quality	④	Q_1	Q_2	1	1	1	1	7	×
Risk	⑧	1	×	×	1	R_1	1	1	8

Table 12. Simulation Result (extracted)

No.	Additional Links								Between-ness: Scope	Comm.	Proc.	Resource	Time	Cost	Qual.	Risk	QCD Vector
1		After Partitioning							0.000	0.750	3.333	6.667	1.750	6.083	1.083	3.333	6.422
2		After Tearing							0.000	0.250	7.333	6.667	2.750	8.583	1.083	0.333	9.078
		D1	C1	Q1	D2	C2	Q2	R1									
10	+ 2	1	1						0.000	0.250	6.250	5.583	3.000	8.833	1.083	0.000	9.391
11		1		1					0.000	0.250	6.200	5.533	2.950	8.583	1.283	0.200	9.166
12		1			1				0.000	0.250	6.583	2.917	4.833	8.083	1.083	0.250	9.480
13		1				1			0.000	0.250	6.583	2.417	2.833	10.583	1.083	0.250	11.009
14		1					1		0.000	0.250	6.583	2.917	3.333	8.583	3.083	0.250	9.710
16			1	1					0.000	0.250	6.250	5.583	2.750	8.833	1.333	0.000	9.347
17			1		1				0.000	0.250	6.667	3.000	4.250	8.750	1.983	0.000	9.928
18			1			1			0.000	0.250	6.667	2.500	2.250	11.250	1.083	0.000	11.524
19			1				1		0.000	0.250	6.667	3.000	2.750	9.250	3.083	0.000	10.131
20			1					1	0.000	0.250	6.667	5.667	3.083	8.750	0.583	0.000	9.296
21				1	1				0.000	0.250	6.583	2.917	4.250	8.983	1.667	0.000	10.076
22				1		1			0.000	0.250	6.583	2.417	2.250	10.583	1.667	0.250	10.947
23				1			1		0.000	0.250	6.583	2.917	2.750	8.583	3.667	0.250	9.730
24				1				1	0.000	0.250	6.583	5.583	3.083	8.083	1.167	0.250	8.729
25					1	1			0.000	0.250	7.333	2.500	3.083	9.417	1.083	0.333	9.968
26					1		1		0.000	0.250	7.333	2.500	3.583	8.083	1.917	0.333	9.047
27					1			1	0.000	0.250	7.333	2.833	5.083	7.583	0.583	0.333	9.148
28						1	1		0.000	0.250	7.333	2.333	2.250	9.750	1.750	0.333	10.158
29								1	0.000	0.250	7.333	2.833	2.583	10.083	0.583	0.333	10.425
30							1	1	0.000	0.250	7.333	3.333	3.083	8.083	2.583	0.333	9.028
31	+ 3	1	1	1					0.000	0.250	6.000	5.333	2.750	8.583	1.083	0.000	9.078
32		1	1		1				0.000	0.250	6.250	2.583	4.500	8.333	1.083	0.000	9.532
33		1	1			1			0.000	0.250	6.250	2.083	2.500	10.833	1.083	0.000	11.170
34		1	1				1		0.000	0.250	6.250	2.583	3.000	8.833	3.083	0.000	9.825
35		1	1					1	0.000	0.250	6.250	5.250	3.333	8.333	0.583	0.000	8.994
36		1		1	1				0.000	0.250	6.200	2.533	4.450	8.083	1.283	0.200	9.316
37		1		1		1			0.000	0.250	6.200	2.033	2.450	10.583	1.283	0.200	10.938
38		1		1			1		0.000	0.250	6.200	2.533	2.950	8.583	3.283	0.200	9.651
39		1		1				1	0.000	0.250	6.200	5.200	3.283	8.083	0.783	0.200	8.759
40		1			1	1			0.000	0.250	6.583	1.750	3.667	9.417	1.083	0.250	10.164
41		1			1		1		0.000	0.250	6.583	1.750	4.167	8.083	1.917	0.250	9.294
42		1			1			1	0.000	0.250	6.583	2.083	5.667	7.583	0.583	0.250	9.485
43		1				1	1		0.000	0.250	6.583	1.583	2.833	9.750	1.750	0.250	10.303
44		1				1		1	0.000	0.250	6.583	2.083	3.167	10.083	0.583	0.250	10.585
45		1					1	1	0.000	0.250	6.583	2.583	3.667	8.083	2.583	0.250	9.244
46			1	1	1				0.000	0.250	6.250	2.583	4.250	8.333	1.333	0.000	9.449
47			1	1		1			0.000	0.250	6.250	2.083	2.250	10.833	1.333	0.000	11.144
48			1	1			1		0.000	0.250	6.250	2.583	2.750	8.833	3.333	0.000	9.833
49			1	1				1	0.000	0.250	6.250	5.250	3.083	8.333	0.833	0.000	8.924
50			1		1	1			0.000	0.250	6.667	1.833	3.083	10.083	1.083	0.000	10.599
51			1		1		1		0.000	0.250	6.667	1.833	3.583	8.750	1.917	0.000	9.648
52			1		1			1	0.000	0.250	6.667	2.167	5.083	8.250	0.583	0.000	9.708
53			1			1	1		0.000	0.250	6.667	1.667	2.250	10.417	1.750	0.000	10.800
54			1			1		1	0.000	0.250	6.667	2.167	2.583	10.750	0.583	0.000	11.071
55			1				1	1	0.000	0.250	6.667	2.667	3.083	8.750	2.583	0.000	9.630
56				1	1	1			0.000	0.250	6.583	1.750	3.083	9.417	1.667	0.250	10.048
57				1	1		1		0.000	0.250	6.583	1.750	3.583	8.083	2.500	0.250	9.188
58				1	1			1	0.000	0.250	6.583	2.083	5.083	7.583	1.167	0.250	9.203
59				1		1	1		0.000	0.250	6.583	1.583	2.250	9.750	2.333	0.250	10.275
60				1		1		1	0.000	0.250	6.583	2.083	2.583	10.083	1.167	0.250	10.474
61				1			1	1	0.000	0.250	6.583	2.583	3.083	8.083	3.167	0.250	9.212
62					1	1	1		0.000	0.250	7.333	2.000	2.750	8.917	1.417	0.333	9.438
63					1	1		1	0.000	0.250	7.333	2.000	3.750	8.750	0.583	0.333	9.538
64					1		1	1	0.000	0.250	7.333	2.000	4.250	7.583	1.250	0.333	8.782
65						1	1	1	0.000	0.250	7.333	2.000	2.583	9.250	1.250	0.333	9.685

Simulation results show that even if the 7 cells (links) Q_1, Q_2, C_1, C_2, D_1, D_2, and R_1 are added into the network system with some conditions, the QCD Betweenness Vector $|P|_T$ value would be maintained as above. For the case where 2 links of $C_1 + C_2$ are added, the best value of the QCD Vector ($|P| = 11.524$) is obtained. Basically, the addition of one further link with $C_1 + C_2$ makes the QCD Vector value higher.

This simulation result suggests that Scope Management and Communication Management support the main QCD Management elements, hence if we require a high efficiency management system for a Project, Scope & Communication Management must be taken into account in the early stage.

6.2 The Optimal PM Configuration for Construction

Figure 6 illustrates the optimal PM for construction configuration in visualized format. It is clear that the 1st generation management is supported by Scope, Communication and Risk, which we would like to call the "Core Management Elements [12]".

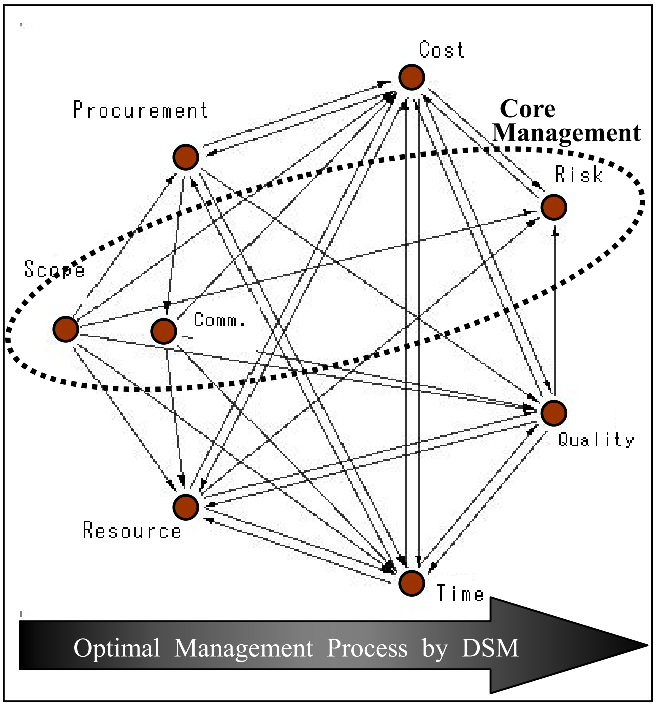


Figure 6. Efficient Management Configuration

7. CONCLUSIONS

The survey results do not provide us the relative importance of Communication and Scope Management, however we do know that 70~90% of a project manager's time is likely to be spent on communication [13] [14]. This is further supported by a USA communication management service on the Internet, which provides an advanced business model [15].

Presentation of analysis data as a Management Matrix and Rader Chart provides us with a simple overview of the characteristics and trends for a project. Through use of the DSM technique and Graph Theory we have further demonstrated that Communication and Scope Management are the core elements with potential for optimization of construction management system and processes.

In this study, we adopted the 8 management elements defined by PMBOK. The combination of these is extremely complex and it is therefore difficult for site managers to optimize management strategies other than through experience and knowledge. We hope that the optimization method we proposed in this paper can assist them as a further tool and reference for the future.

We have described the effective adoption of a Management Matrix, DSM and Graph Theory for the optimization of Project management within the Construction industry, and we believe our proposed logic should be widely applicable to other complicated business fields as long as the characteristics can be translated into a binary square matrix.

Finally, as all stakeholders are concerned with the transparency, efficiency and fairness of public infrastructure development, it is essential that there is continuous and clear communication of information throughout the Project Life Cycle Time.

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