

## CHAPTER 7

### 7.0. CONCLUSIONS

#### 7.1. THE SUMMARY

Quality was considered an important area to research on as it is a major consideration in any building project. The intention of this study has been to identify the quality problems in the state sector building projects and then to investigate how they can be prevented.

At the inception of the research, it was found that firstly quality has to be defined objectively. Investigations revealed that the problem of defining quality is more acute in the building industry than in other sectors because the total responsibility for the creation of a building is divided between many different people and organisations. However, 'Conforming to predetermined requirements' has been found as the most appropriate definition to be adopted in this study. Given this definition, literature review revealed that there are three main requisites of quality viz:

- Effective and efficient communication between the three main parties to a project namely, client, consultant and the contractor.
- Possessing of the required skills and knowledge by all the parties to a project

and

- Making necessary changes in cultural attitude by everyone involved in a project.

To cover the above stated requisites, a conceptual framework was worked out covering six main stages in the life cycle of a project through which a chain of conformance should be carried out. Each stage consists of a series of tasks which should be carried out in the sequence identified. But the study revealed that due to the number of tasks being very large, it will not be easy to apply this in practice. Based on this concept, a model can be developed to apply to projects. This is an area for further research.



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The empirical study revealed that for the three main project participants namely the client, consultant and the contractor, quality is equally important. Also, for them, some quality problems are more important than the others.

For project participants, lack of communication and coordination, poor documentation and poor supervision of works are the most important causes of quality problems according to literature review and questionnaire survey. However, beuaracracy, political interference too are highlighted as major causes of quality problems in the state sector projects.



The least important cause of quality problems is the effect of international standards: ISO 9000. Therefore, there was no evidence to confirm that ISO 9000 will help to achieve quality. The study also confirmed the fact that all involved in a project has equal responsibility towards quality.

## 7.2. MAIN CONCLUSIONS

The main conclusions of the study are:

- Quality can be achieved in a building project, if everyone involved in the project is committed, trained and knowledgeable and follow correct procedures for all their work and who will:
  - Communicate and coordinate well throughout every stage of the project
  - have a good documentation system
  - Take equal responsibility
  - Believe that commitment to quality is required throughout the entire process if quality is to be achieved in the final product.


- Quality management is a systematic process control throughout each stage of a project. If its principles are properly understood the end result will be a quality building. To achieve this, all the participants must play their part in making the necessary cultural change in attitude.

This study raised a very important issue in the achievement of quality viz; a change in cultural attitude, an issue which requires further investigations. 'How to develop a quality culture in the building industry' is a suitable area for future research. Furthermore, it will be necessary to compare the importance of each main requirement of quality given in the above conclusion and their relationship to cultural attitude. Then it will be possible to find out whether a change in cultural attitude will solve all other above stated quality problems satisfying all other requirements. If this is so, questions that could be raised are:

- Is achievement of quality a social problem requiring a change in cultural attitude, and not anything else?
- If a change in cultural attitude takes place, will everyone communicate and coordinate well, have good documents, take equal responsibility, believe that commitment to quality is required, and then achieve quality.

### 7.3. LIMITATIONS OF THE STUDY

The main limitations of the study are:

1. The number of questionnaire surveys is insufficient to make firm conclusions.
2. Case studies do not cover a wide area even within the state sector. The effects of the private sector consultants are not measured.
3. In the case studies, the participant organisations are not ISO certified. Therefore, the effect of this could not be measured.  
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4. Only the main participants are considered. Users, manufacturers of products, subcontractors and suppliers are not considered.
5. Only the pre construction and construction stages are considered. Maintenance stage and feasibility stage are not considered.
6. Various differences in the outcome of the three types of enquiry viz; literature review, questionnaire survey and case studies are not investigated.

In conclusion, this research has examined factors which affects quality of buildings and possible solutions. It has also described the current state of knowledge on the subject of quality, supplemented by empirical investigations. It is hoped that this work will have practical applications in the creation of quality buildings.



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## REFERENCES

### BOOKS

Ashford, J.L. (1989), *The Management of Quality in Construction*. E&F.N. Spon Publication, London.

Bell, D, McBride, P and Wilson, G. (1994), *Managing Quality*. Butterworth - Heinemann Ltd.

Cornick, Tim. (1991), *Quality Management for Building Design*. Butterworth Heinemann.

Dediyagala, N., (1998), *Research Methodology for Management*. S. Godage & Brothers, Colombo, Sri Lanka.

Deming, W.E., (1988), *Quality, Productivity and Competitive Position*. Cambridge University Press, Cambridge.

Griffith, Alan., (1990), *Quality Assurance in Building*. Macmillan Education Ltd, London.

Garvin, D.A., (1982), *Managing Quality*. The Tree Press, London.

Juran, J.M., (1988), *Juran's Quality Control Handbook* (4th Edition). McGraw Hill, New York.

Levine, H.A., (1986), *Project Management using Computers*. McGraw Hill, Berkeley, California.

Pascale, R.T. and Athos, A.G. (1981), *The art of Japanese Management*. Simon and Schuster, New York.

Peters, T.J. and Waterman, R.H. (1982), *In search of excellence; Lessons from America's best run companies*. Harper & Row, New York.

Sadgrove, Kit., (1994), *ISO 9000 BS5750; A Practical Guide to Quality*. Kogan Page Ltd.

Statiowiski, Frank, A. and Burstein, P.E. (1994), *Total Quality Project Management for the Design Team*. John Wiley & Sons, Inc.

Wah Law Siew, Low Chin Min & Teng Wye Ann. (1994), *ISO 9000 in Construction*. McGraw Hill Co, Singapore.

Walker, A. (1984), *Project Management in Construction*. Granada Publishing Co.

## *JOURNALS*

Aniftos, S. and Yates, K., (1997), *International Standards and Construction*. Journal of construction engineering and management, June, P 127 - 137.

Kumaraswamy, M., *Quality Management Systems in Construction Organisations - Their Introduction and Implementation*, (1996), Engineer, Journal of the Institution of Engineers, Sri Lanka, June, P 30 - 44.

Parti, E.W., (1996), *Issues in Pursuing Quality in Facility Program Development*. Journal of architectural engineering, March, P 32 - 40.



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## ***BIBLIOGRAPHY***

### ***BOOKS***

Crosby, P.B. (1979), *Quality is free*. New York: McGraw Hill.

Juran, J.M. (1979), *Quality Planning and Analysis*. New York: McGraw Hill.

Harris, F. and McCaffer, R. (1995), *Modern Construction Management*. Blackwell Science, Oxford.

Kohoe, D.F., (1996), *The Fundamentals of Quality Management*. Chapman & Hall.

Lock, Dennis., (1994), *Hand book of Project Management*. Gower Publishing Co. Ltd.

Taylor, M. and Hoister, H.H., (1992), *Quality Assurance for Building Design*. Longman Scientific and Technical, U.K.

Thompson, A., (1990), *Architectural Design Procedures*. Edward Arnold.

## **JOURNALS**

Amaradasa, A.A. (1997), *Bringing about the Total Quality Cultural Change*. Quality Today, P5-8.

Chase G.W. (1993), *Effective Total Quality Management Process for Construction*., Journal of management in engineering, Vol. 9, P.433-444.

De Silva, Sri Lal., (1998), *Strengths and Weaknesses of ISO 9000 Certification in Sri Lanka*. Seminar on ISO 9000 Series of Standards - Sri Lankan experience, Organised by the Sri Lanka Association for Quality.

Gordon, Anne S. and Jim A. (1993), *Implementing TQM in Consultancy Engineering Firm*., Journal of engineering in management, Vol. 9, Page 340 - 357.

Hockman, K.K. (1992), *ISO 9000: Opportunity or nightmare?* ISO 9000 News, Vol. No. 1 January, P 2-3.

James L., Burati Jr., Michel F., Mathews, and Satyanarayan N. Kalidindi., (1992), *Quality Management Oorganisations and Techniques*., Journal of construction engineering and management, Vol. 118, No. 1.

James L.B., (1993), *Implementing TQM in Engineering & Construction*., Journal of management in engineering Vol. 9, P.456-471.

Low S.P., (1993), *The Rationalization of Quality in the Construction Industry: Some Empirical Findings*., Construction Management and Economics, Vol. 11, P 247 - 259.

Mark O.F. and Gerald W.C. (1993), *Applyinig Total Quality Management to Design and Construction*., Journal of management in engineering, Vol. 9, P 357 - 365.

Melville H., (1993), *Essential Tool of Total Quality Management*., Journal of management in engineering, Vol. 9, P 329 - 340.

*The Control of Quality of Quality on Construction Sites*, (1996), Construction Industry Research and Information Association, Special Publication 140, CIRIA, London.

*Quality Assurance Systems for Construction Industry.* (1994), Unpublished Seminar Papers, ICTAD, Ministry of Local Govt. Housing & Construction.

*Quality Assurance in Construction,* (1998), Institution of Civil Engineers, Sri Lanka, Proceedings of the Conference.



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APPENDIX I - SAMPLE QUESTIONNAIRE

QUESTIONNAIRE

1.0 Please indicate your relationship to the building industry.

- |                   |                          |                 |                          |
|-------------------|--------------------------|-----------------|--------------------------|
| Architect         | <input type="checkbox"/> | Client          | <input type="checkbox"/> |
| Engineer          | <input type="checkbox"/> | Project Manager | <input type="checkbox"/> |
| Quantity Surveyor | <input type="checkbox"/> | Contractor      | <input type="checkbox"/> |

2.0 Do you agree in saying that present day clients are more concerned about quality in buildings?

- Yes
- No
- Don't know

3.0 Please rank following main quality problems of a building.

- 1) Does not conform to functional requirements of the building.  
(eg:spaces inadequate)
- 2) Aesthetically not very pleasing
- 3) Technically unsatisfactory (eg:Structural strength,services such as lighting and ventilation etc)
- 4) Workmanship unsatisfactory
- 5) Building products and components not to accepted standards.
- 6) Maintenance difficult
- 7) Other

4.0 Most quality problems occur during which stage of a building project?

- Preconstruction
- Construction stage

5.0 Do you think most quality problems in the construction stage can be prevented in the

- Preconstruction stage? Yes
- No
- Don't know

6.0 Why do you say so? Please give reasons.

7.0 Rank order following according to their importance in a building project.

Completion within the stipulated time

Completion within the budgeted cost

Achieving quality

8.0 Please rank following main reasons for quality problems.

1) Lack of communication and coordination between parties to a building project

2) Lack of skill and care

3) Technological factors

4) Poor documentation(Drawings, Specifications etc)

5) Poor supervision of construction works

6) Non consideration of local/international standards

7) All above reasons are equally important

8) Other

9.0 Do you agree in saying that most quality problems can be solved in the design stage?

Yes

No

Don't know

10.0 Please give reasons for your answer to question 9.0.

11.0 Are you familiar with the term 'Quality Management' which means systematic process control throughout every phase of a building project?

Yes

No

12.0 If your answer to question 11 is Yes, then do you think quality management from inception to completion of a building project is the answer to quality problems of a building?

Yes

No

Don't know

13.0 Do you think that all 3 parties namely, client, consultant and the contractor are equally responsible for quality.

Yes

No

Don't know



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14.0 Rank following parties to a building project in order of their contribution in achieving quality.

Client  Consultant

Contractor  All three parties are equally important

15.0 Do you agree that in relation to buildings, international standards such as ISO 9000 will increase in importance with time?

Yes

No

Don't know

16.0 Are you familiar with the ISO 9000 standards?

Yes

No

17.0 Is your organisation thinking of obtaining ISO9000 certification?

Yes

No



18.0 Do you think that the implementation of ISO 9000 would improve quality of buildings?

Yes

No

Don't know

19.0 Please give reasons for your answer to question 18.0.

20.0 What do you think of following?

ISO 9000 is:

- |   |                              |                             |
|---|------------------------------|-----------------------------|
| 1. Too complicated and difficult to apply.  | Yes <input type="checkbox"/> | No <input type="checkbox"/> |
| 2. It is only paper work  | Yes <input type="checkbox"/> | No <input type="checkbox"/> |
| 3. It is expensive to implement   | Yes <input type="checkbox"/> | No <input type="checkbox"/> |
| 4. It will restrict innovative design   | Yes <input type="checkbox"/> | No <input type="checkbox"/> |
| 5. It is more suitable for manufacturing industry and<br>not suitable for building projects | Yes <input type="checkbox"/> | No <input type="checkbox"/> |
| 6. It will reduce time taken for a project  | Yes <input type="checkbox"/> | No <input type="checkbox"/> |
| 7. It will reduce personnel required for a project  | Yes <input type="checkbox"/> | No <input type="checkbox"/> |
| 8. It will use quality products in a building   | Yes <input type="checkbox"/> | No <input type="checkbox"/> |
| 9. It will improve competitiveness of the company   | Yes <input type="checkbox"/> | No <input type="checkbox"/> |
| 10. It will reduce errors   | Yes <input type="checkbox"/> | No <input type="checkbox"/> |
| 11. It will increase productivity   | Yes <input type="checkbox"/> | No <input type="checkbox"/> |
| 12. It will result in cost reduction of a project   | Yes <input type="checkbox"/> | No <input type="checkbox"/> |

THANK YOU FOR YOUR COOPERATION.

Vasanth De Silva

## APPENDIX 2 - STATISTICAL ANALYSIS

### Question 1

#### Profession

	No.	%
Consultant	13	61.90
Clients	5	23.81
Contractors	3	14.29
Total	21	100.00

### Question 2

Yes	18	90.00
No	2	10.00
Total	20	100.00

### Question 7

#### Time

	No.	%
Most important	1	5.00
Moderately important	6	30.00
Least important	13	65.00
Total	20	100.00



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#### Cost

	No.	%
Most important	1	5.00
Moderately important	12	60.00
Least important	7	35.00
Total	20	100.00

#### Quality

	No.	%
Most important	18	90.00
Moderately important	2	10.00
Total	20	100.00



ROWS: prof COLUMNS: time

	1	2	3	ALL
1	1	3	8	12
2	0	0	5	5
3	0	3	0	3
ALL	1	6	13	20

ROWS: prof COLUMNS: cost

	1	2	3	ALL
1	1	7	4	12
2	0	5	0	5
3	0	0	3	3
ALL	1	12	7	20

ROWS: prof COLUMNS: quality

	1	2	ALL
1	10	2	12
2	5	0	5
3	3	0	3
ALL	18	2	20



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Kruskal Wallis Test to compare three criteria (Time, Cost, Quality)

LEVEL	NOBS	MEDIAN	AVE. RANK	Z VALUE
1	20	3.000	42.5	3.76
2	20	2.000	36.5	1.88
3	20	1.000	12.5	-5.65
OVERALL	60		30.5	

$H = 33.05$  d.f. = 2  $p = 0.000$

$H = 37.17$  d.f. = 2  $p = 0.000$  (adj. for ties)

All three criteria are not equally important under 5% level of significance  
To check whether three groups considered have the same attitude on time

LEVEL	NOBS	MEDIAN	AVE. RANK	Z VALUE
1	12	3.000	10.5	0.04
2	5	3.000	14.0	1.53
3	3	2.000	4.5	-1.91
OVERALL	20		10.5	

H = 4.84 d.f. = 2 p = 0.090  
 H = 6.91 d.f. = 2 p = 0.032 (adj. for ties)  
 No. (Under 5% level of significance)

To check whether three groups considered have the same attitude on cost

LEVEL	NOBS	MEDIAN	AVE. RANK	Z VALUE
1	12	2.000	10.1	-0.35
2	5	2.000	7.5	-1.31
3	3	3.000	17.0	2.06
OVERALL	20		10.5	

H = 4.96 d.f. = 2 p = 0.084  
 H = 6.67 d.f. = 2 p = 0.036 (adj. for ties)  
 No (Under 5% level of significance)

To check whether three groups considered have the same attitude on quality

LEVEL	NOBS	MEDIAN	AVE. RANK	Z VALUE
1	12	1.000	11.2	0.62
2	5	1.000	9.5	-0.44
3	3	1.000	9.5	-0.32
OVERALL	20		10.5	



H = 0.38 d.f. = 2 p = 0.827  
 H = 1.41 d.f. = 2 p = 0.495 (adj. for ties)  
 Yes (Under 5% level of significance)

### Question 3

#### Reason 1

1	5	25.00
2	4	20.00
3	4	20.00
4	4	20.00
5	3	15.00
ALL	20	100.00

#### Reason 2

1	1	5.00
2	1	5.00
3	1	5.00
4	3	15.00
5	6	30.00
6	8	40.00
ALL	20	100.00

Reason 3

1	3	15.00
2	4	20.00
3	3	15.00
4	2	10.00
5	2	10.00
6	6	30.00
ALL	20	100.00

Reason 4

1	5	25.00
2	5	25.00
3	5	25.00
4	2	10.00
5	2	10.00
6	1	5.00
ALL	20	100.00

Reason 5

1	2	10.00
2	3	15.00
3	2	10.00
4	7	35.00
5	4	20.00
6	2	10.00
ALL	20	100.00



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Reason 6

1	4	20.00
2	3	15.00
3	5	25.00
4	2	10.00
5	2	10.00
6	4	20.00
ALL	20	100.00

To test whether all six reasons are equally important

LEVEL	NOBS	MEDIAN	AVE. RANK	Z VALUE
1	20	3.000	46.4	-1.98
2	20	5.000	86.2	3.61
3	20	3.500	64.3	0.54
4	20	2.500	44.4	-2.26
5	20	4.000	64.3	0.54
6	20	3.000	57.3	-0.44

OVERALL 120 60.5

H = 19.07 d.f. = 5 p = 0.002

H = 19.61 d.f. = 5 p = 0.002 (adj. for ties)

No. (at 5% level of significance)

#### Question 4

Yes	9	45.00
No	11	55.00
ALL	20	100.00

ROWS: prof COLUMNS: q4

1	7	6	13
2	0	4	4
3	2	1	3
ALL	9	11	20



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#### Question 5

Yes	19	90.48
No	2	9.52
ALL	21	100.00

ROWS: prof COLUMNS: Q5

1	11	2	13
2	5	0	5
3	3	0	3
ALL	19	2	21

#### Question 9

Yes	16	76.19
No	5	23.81
ALL	21	100.00

### Question 8

#### reason 1

	COUNT	%
1	4	26.67
2	3	20.00
3	1	6.67
4	3	20.00
5	1	6.67
7	3	20.00
ALL	15	100.00

Ranking varies from 1 to 7 and the percentages are somewhat similar. Therefore, it can be concluded that there is no agreement in ranking this reason.

#### reason 2

	COUNT	%
1	4	26.67
2	1	6.67
3	1	6.67
4	4	26.67
5	2	13.33
6	1	6.67
7	2	13.33
ALL	15	100.00

Ranking varies from 1 to 7 and the percentages are somewhat similar. Therefore, it can be concluded that there is no agreement in ranking this reason.

#### reason 3

	COUNT	%
3	1	6.67
4	3	20.00
5	5	33.33
6	4	26.67
7	2	13.33
ALL	15	100.00

Most respondents rank this reason as the fifth cause of the quality problems.

reason 4

	COUNT	%
1	4	26.67
2	1	6.67
3	6	40.00
4	1	6.67
5	1	6.67
6	1	6.67
7	1	6.67
ALL	15	100.00

Most respondents rank this reason as the third cause of the quality problems.

reason 5

	COUNT	%
1	2	13.33
2	2	13.33
3	6	40.00
4	2	13.33
5	3	20.00
ALL	15	100.00

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Most respondents rank this reason as the third cause of the quality problems.

reason 6

	COUNT	%
2	2	13.33
4	1	6.67
5	2	13.33
6	8	53.33
7	2	13.33
ALL	15	100.00

Most respondents rank this reason as the sixth cause of the quality problems.

reason 7

	COUNT	%
1	1	6.67
2	6	40.00
4	1	6.67
5	1	6.67
6	1	6.67
7	5	33.33
ALL	15	100.00

Most respondents rank this reason as the second cause of the quality problems.

ROWS: Professi COLUMNS: r1

	1	2	3	4	5	7
ALL						
1	1	0	0	0	0	1
2	1	3	1	2	1	0
8	3	2	0	0	1	2
5	ALL	4	3	1	3	3
15						



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ROWS: Professi COLUMNS: r2

	1	2	3	4	5	6
7	ALL					
0	1	0	0	0	1	0
2	2	2	0	0	2	2
2	8	2	1	1	1	0
0	5	2	1	1	1	0
2	ALL	4	1	1	4	2
15						

ROWS: Professi COLUMNS: r3

	3	4	5	6	7	ALL
1	0	0	2	0	0	2
2	1	1	1	3	2	8
3	0	2	2	1	0	5
ALL	1	3	5	4	2	15

ROWS: Professi		COLUMNS: r4					
		1	2	3	4	5	6
7	ALL						
	1	0	0	1	0	0	0
1	2	4	1	2	1	0	0
0	8	0	0	3	0	1	1
0	5	4	1	6	1	1	1
1	ALL	4	1	6	1	1	1
	15						

ROWS: Professi		COLUMNS: r5					
		1	2	3	4	5	ALL
	1	1	0	1	0	0	2
2	0	1	4	2	1	1	8
3	1	1	1	0	2	2	5
ALL	2	2	6	2	3	3	15

ROWS: Professi		COLUMNS: r6					
		1	2	3	4	5	ALL
	2	1	0	0	1	0	2
1	1	0	2	4	1	1	8
2	1	0	1	0	3	1	5
3	0	1	2	8	2	2	15
ALL	2	1	2	8	2	2	15

ROWS: Professi		COLUMNS: r7					
		1	2	4	5	6	7
ALL							
	1	0	1	1	0	0	0
2	2	1	2	0	1	1	3
8	3	0	3	0	0	0	2
5	ALL	1	6	1	1	1	5
15							

MTB > desc c2-c8

MEDIAN





r1	3.000
r2	4.000
r3	5.000
r4	3.000
r5	3.000
r6	6.000
r7	4.000

The above table shows that reasons 1, 4, 5 are the most important reasons. They are equally important. Reason 2 and 7 are also equally important. Least important reason is the sixth reason. The order of importance is shown below.

Reason 1,4, 5 > Reason 2, 7 > Reason 3 > reason 6

	Professi	MEDIAN
r1	1	4.00
	2	2.500
	3	4.00
r2	1	5.00
	2	4.500
	3	2.000
r3	1	5.00000
	2	6.000
	3	5.000
r4	1	5.00
	2	1.500
	3	3.000
r5	1	2.00
	2	3.000
	3	3.000
r6	1	4.00
	2	6.000
	3	6.000
r7	1	3.00
	2	5.500
	3	2.00

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ROWS: prof COLUMNS: Q9

1	9	4	13
2	5	0	5
3	2	1	3
ALL	16	5	21

Question 11

Yes	18	85.71
No	3	14.29
ALL	21	100.00

ROWS: prof COLUMNS: Q11

1	10	3	13
2	5	0	5
3	3	0	3
ALL	18	3	21

Question 12

Yes	18	85.71
Don't know	3	14.29
ALL	21	100.00



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ROWS: prof COLUMNS: Q12

1	10	3	13
2	5	0	5
3	3	0	3
ALL	18	3	21

Question 13

Yes	13	61.90
No	3	14.29
3	5	23.81
ALL	21	100.00

ROWS: prof COLUMNS: Q13

1	7	1	5	13
2	5	0	0	5
3	1	2	0	3
ALL	13	3	5	21

Question 14

3	8	38.10
4	13	61.90
ALL	21	100.00

ROWS: prof COLUMNS: Q14

1	4	9	13
2	4	1	5
3	0	3	3
ALL	8	13	21

Question 15

Yes	13	61.90
Don't know	8	38.10
ALL	21	100.00

ROWS: prof COLUMNS: Q15

1	11	2	13
2	1	4	5
3	1	2	3
ALL	13	8	21



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Question 16

Yes	7	33.33
No	14	66.67
ALL	21	100.00

ROWS: prof COLUMNS: Q16

1	6	7	13
2	0	5	5
3	1	2	3
ALL	7	14	21

Question 17

Yes	7	35.00
No	13	65.00
ALL	20	100.00

ROWS: prof COLUMNS: Q17

1	6	6	12
2	0	5	5
3	1	2	3
ALL	7	13	20

Question 18

Yes	7	35.00
No	1	5.00
Don't know	12	60.00
ALL	20	100.00

ROWS: prof COLUMNS: Q18

1	6	1	5	12
2	0	0	5	5
3	1	0	2	3
ALL	7	1	12	20



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## A NOTE ON THE STATISTICAL TESTS

In the study, the variables are recorded either in nominal scale or ordinal scale. The best measure of central tendency for nominal scale data is the mode. Therefore, in the presentation of data frequency tables are used. When the data are recorded in ordinal scale, the best measure of central tendency is the median. Therefore, all the comparisons were performed using the median as the measure of central tendency. In testing hypothesis, nonparametric statistical tests are used instead of popular parametric statistical tests such as t-test and ANOVA, due to the following two reasons.

1. The scale of measurement used are either nominal or ordinal
2. The number of observations are small

Kruskal-Wallis one way ANOVA was used to compare the central tendency of several groups. Minitab (Version 7) was used to perform the analysis. A Kruskal-Wallis test is a K-sample generalization of the Mann-Whitney-Wilcoxon test and thus offers a nonparametric alternative to the usual one-way analysis of variance. The test assumes that the data arise as K independent random samples from continuous distributions all having the same shape. The null hypothesis of no differences among the K population locations is tested against the alternative of at least one difference.

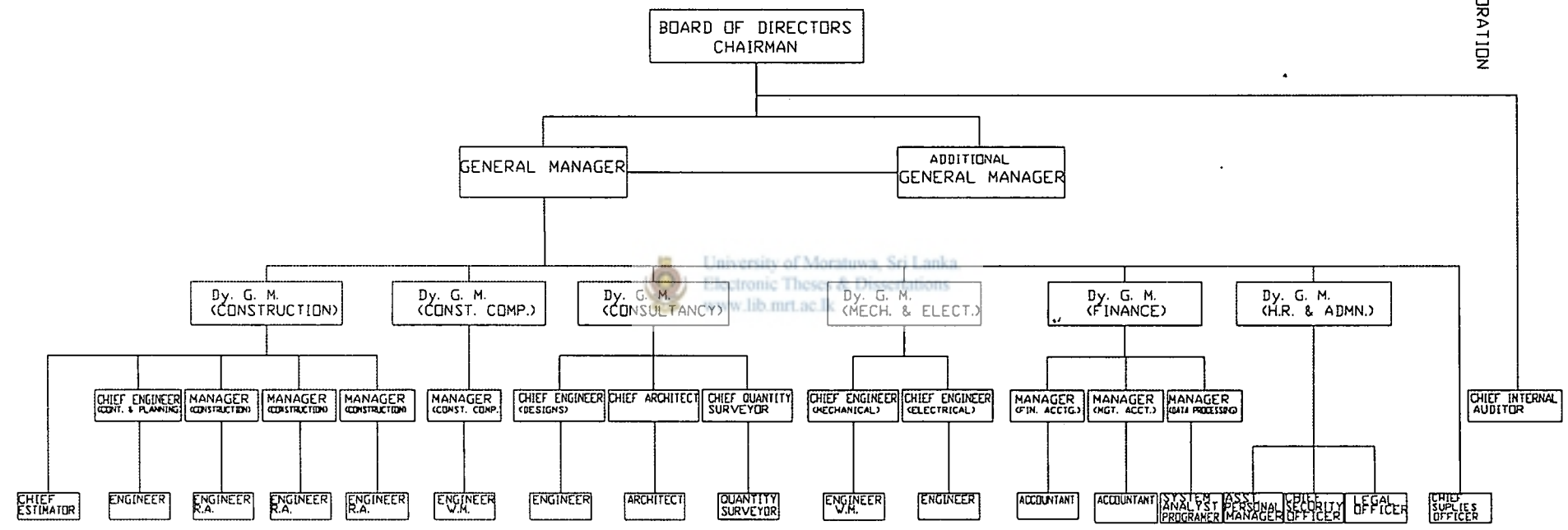
First, all observations are ranked (tied observations are given the average rank). For each level, the average,  $R_{\text{bar } i}$ , of all ranks in level i is calculated. The following z-value is also calculated:

$$z_i = (R_{\text{bar } i} - (N+1)/2) / \text{SQRT}((N+1)((N/N_i) - 1)/12)$$
, where  $N_i$  = number of observations for level i and N = total number of observations. Under  $H_0$ ,  $z_i$  is approximately normal with mean 0 and variance 1.

The Kruskal-Wallis test statistic is H. Under the null hypothesis, H can be approximated by a chisquare distribution with k-1 degrees of freedom. The approximation is good if each group has at least 5 observations. H(Adjusted for ties) also has an approximately chisquare distribution with k-1 degrees of freedom, under  $H_0$ . Minitab prints H adjusted for ties if there are ties.



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