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A STUDY ON FACTORS AFFECTING DESIGN-CONSTRUCTION INTERFACE

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ABSTRACT: - *This study focuses on the factors that affects design-construction interface in construction industry. To accomplish study objectives, literature reviews and Pilot studies were carried out and based on that survey questionnaire was developed. Data collection was conducted through online survey and direct interviews. Responses from twenty companies were analyzed through Relative Importance Index method. The results indicate that design complexity, time limitation in the design phase, lack of accuracy in specification and working drawings, lack of communication between designer and owner's family & participants' honest wrong beliefs are the most important problems that affects design-construction interface. Whereas, effect of material changes during construction, weather conditions, involvement of the contractor in the design conceptual phase and development phase revealed as least important problems. In conclusion, frequent professional meetings, maximizing standardization, regular safety meetings and preconstruction exercise done prior to any construction activity can reduce the severity of these problems.*

Keywords – design complexity, design-construction interface

INTRODUCTION

Construction industry is one of the key industries of any country. But constructions are becoming more and more complex these days. But one of the main problems in construction industry is the construction of buildings as per the design. Problems mainly take place intermediate to the design phase and construction phase. To eliminate these problems it must be identified. Once the problems are identified it is easy to prevent their occurrence. For this reason effective construction management is essential which deals with identifying the factors that cause these problems and avoiding them. This thesis is a study of the design-construction interface in construction industry. The main objective of the thesis is:

- To identify the problems that affects design-construction interface.
- To analyze these factors and to find the most important factors
- To provide suggestions and recommendations to eliminate the problems at the design-construction interface.

REVIEW OF LITERATURE

Fu-Cih Siao et al., (2004) says that based on good integration of interfaces, there are positive benefits for the use of the resource, the constructability and the construction schedule etc. And further to affect the project cost.

Luis F. Alarcon and Daniel A. Mardones (1998) conducted a performance study of the design-construction interface. A review of the most frequent design defects found during the construction phase in four building allowed the researchers to design several tools to

prevent the occurrence of these defects. The proposed changes were implemented in a construction company participating in study with significant impact on performance. The implementation comprised new design and review procedures, standards for communication as well as explicit definition of internal customer requirements and design attributes. The implementations helped the company to avoid rework and all type of waste in both the designer office and the construction site.

Eric Johansen and John Carson (2003) says that there are many factors which contribute design management and quality of design and documentation but in the main they do not add value to design process and there is a need of an impingement in contractors performance in terms of safety, time , cost and quality to improve design-construction interface. They have concluded that in order to improve the , the most significant concepts which need attention are , the design time available, the quality of briefing, the need for a team approach that a clearly identified competent manager controls the process and that the task dependencies are understood.

Mohammad Mryyian1 and Patricia Tzortzopoulos (2013) conducted a study to develop a framework to support designers to identify sources of errors and reduce waste through different design phases. Results demonstrate perceptions that the main causes of errors and waste are related to (a) client changes; (b) design drawing and detail issues; and (c) problems with following regulations and building codes.

Abdul-Mohsen AI-Hammad and Ibrahim AI-Hammad (1996) conducted a study with an objective to identify and assess the relationship between building owners and designers in tens of their interface problems. This study says that interface problems between owner and designer mainly comes under three categories namely: inadequate contract and specifications, financial problems, and lack of proper communication. They concluded that lack of accuracy in specification and working drawings, change orders, lack of proper communication etc. are the most important problems between owners and designers.

Aina, O.O. And Wahab, A.B. (2001) conducted a study that examined the occurrence of buildability problems and the factors that cause buildability problems in construction projects in Nigeria. The study shows that the complexity of project, faulty and defective working drawings, resistance of client to buildability programmes, budgetary limitation and non-standardization of design are ranked most as the cause of buildability problems. The study concludes that working drawings, specifications and other contract documents must be prepared by construction professionals; they should be aware of the likely impacts of buildability problems and the communication skill among construction parties must be effective at all stages of construction projects.

Fu-Cih Siao and Yu-Cheng Lin (2010) says that interface management plays an important role in construction management due to construction projects tend to be complex. This study presents a Construction Interface Matrix (CIM) approach to represent the interface issue-related information for project participants which enables project participants and managers to directly acquire available information for managing interfaces efficiently without other data supporting. Overall, through utilizing the CIM approach, users can directly and efficiently acquire information related to the interface relationships among participants and interface conditions throughout a project.

V.senthil kumar and koshy Varghese (2008) says that complex information intensive and dynamic nature of the fast track concurrent construction design process makes it hard to manage the information flows using the traditional project management techniques and tools. This paper proposes a new methodology 'DIMS' for managing dynamic design information in the detailed design phase. It has five main components, (i) Identification/Definition of project elements, (ii) Development of the Physical Interface Matrix (PIM): capturing the physical interfaces among the components, (iii) Development of Design Interface Matrix (DIM): capturing the design interfaces between the components and the disciplines, (iv) Development of Design Interface Agreement (DIA): capturing the detailed design interface parameters, (v) Developing Drawing DSM: capturing the design interfaces between the drawings and its Optimization to ensure optimal drawing release sequences.

Wai kiong chong and sui pheng low (2006) conducted a research study on design and construction interface dissonances in large building projects in the contextual boundaries of Eastern province of Saudi Arabia. The results indicate that lack of coordination, insufficient working drawing details, involvement of designer as consultant, involvement of contractor as consultant & participants' honest wrong beliefs are considered as most important origins of professional dissonances on project design and construction interfaces. Whereas the project management as individual professional service, nationality of professional firms & involvement of contractor in design phases are interestingly revealed as least important origins of dissonances between professionals on project design and construction interfaces in large building projects.

METHODOLOGY ADOPTED

This research involves evaluation of the interface between design and construction and also identifies the potential causes of discrepancies at the interface between design and construction. The preliminary insight of the subject data for this study has been collected through a literature. Through literature and pilot studies various causes dominating design construction interface issues have been identified and based on those causes a questionnaire has been prepared to analyze the causes of discrepancy based on the response from design consultants, contractors skilled labours and clients.

STEPS INVOLVED

1. Literature survey and pilot studies
2. Identification of factors affecting design-construction interface
3. Prepare questionnaire related to factors
4. Conducting direct interviews and online surveys
5. Data collection from respondents
6. Data analysis using Relative Importance Index method
7. Suggestion for improvement of design-construction interface

RESEARCH METHODOLOGY

- **DATA COLLECTION**

From literature reviews and pilot studies conducted, 35 major factors contributing design-construction interface problems were selected. Based on this factors questionnaire is prepared. Questionnaire includes preference survey which shows the severity of the corresponding factor in design-construction interface. For collecting the data for this project, 30 companies were selected which include large, medium and small scale companies. 20 companies responded through direct

interviews and on-line surveys. And the collected data were analyzed using Relative Importance Index (RII) method.

TABLE 1 Factors affecting design-construction interface

Sl.n	Factors
	Factors related to designers
1	Lack of accuracy in specification and working drawings
2	Involvement of contractor in design conceptual phase.
3	Time limitation in design phase
4	Involvement of contractor in design development phase
5	Lack of communication between designer and owner's family
6	Influence of buildability
7	Design changes by the owner
8	Lack of human resources in design firm
9	Design complexity
10	Owner's desire to modify the use of space after design process
	Factors related to contractors
11	Inappropriate selection of construction materials by designer
12	Inaccurate estimation of project costs by designer
13	Delay in completion of design services
14	Lack of cost indexes for material, labor, and equipment to be used by designer for cost estimation.
15	Designers lack of experience
16	Design complexity
17	Problems with the materials in the market
18	Procurement delays during construction phase
19	Effect of material changes during construction phase
	Factors related to skilled labours
20	Lack of tools and equipment by contractors
21	Shortage of construction materials
22	Lack of skilled manpower
23	Weather conditions
24	Material approval

25	Construction errors at jobsite
	Factors related to clients
26	Poorly written contract agreement document between owner and designer
27	Inappropriate selection of construction materials by designer
28	Owner's low budget for design services relative to requirements
29	Design changes by the owner
30	Slowness of owner's acceptance of final design
31	Inaccurate estimation of project cost by designer
32	Insufficient design communication aids between designer and owner
33	Lack of communication b/w designer and owner's family
34	Designers lack of experience
35	Participants honest wrong belief

- **DATA ANALYSIS METHOD**

The relative importance index method used to determine the relative importance of the various factors that affect design-construction interface. This method was adopted in this study within various groups (clients, consultants, contractors & labours). The three-point scale ranged as 1 (lower), 2 (medium), 3(higher) were adopted and transformed to relative importance indices (RII) for each factor as follows:

$$RII = \sum W / A * N$$

Where W is the weighting given to each factor by the respondents (ranging from 1 to 3), A is the highest weight (i.e. 3 in this case), and N is the total number of respondents. The RII value had a range from 0 to 1 (0 not inclusive), higher the value of RII, more important was the cause or effect. The RII was used to rank the different factors. These rankings made it possible to cross-compare the importance of the factors as perceived by the four groups of respondents (i.e. clients, consultants, contractors & labors).

ANALYSIS & RESULTS

Data collected from 20 respondents were analyzed using Relative Importance Index method. The RII value of factors under each category is shown in table 2. This RII value explains how far the factors affect design-construction interface in construction industry.

TABLE 2 RII value and rank of each factor

Factors	RII	Rank
1. Lack of accuracy in specification and working drawings	0.87	2
2. Involvement of contractor in design conceptual phase.	0.47	20
3. Time limitation in design phase	0.883	1
4. Involvement of contractor in design development phase	0.43	21
5. Lack of communication between designer and owner's family	0.85	3
6. Influence of buildability	0.63	13
7. Design changes by the owner	0.80	6
8. Lack of human resources in	0.817	5

design firm		
9. Design complexity	0.883	1
10. Owner's desire to modify the use of space after design process	0.817	5
11. Inappropriate selection of construction materials by designer	0.5	18
12. Inaccurate estimation of project costs by designer	0.58	16
13. Delay in completion of design services	0.57	17
14. Lack of cost indexes for material, labor, and equipment to be used by designer for cost estimation.	0.75	8
15. Designers lack of experience	0.68	11
16. Design complexity	0.85	3
17. Problems with the materials in the market	0.78	7
18. Procurement delays during construction phase	0.67	12
19. Effect of material changes during construction phase	0.52	19
20. Lack of tools and equipment by contractors	0.62	14
21. Shortage of construction materials	0.8	6
22. Lack of skilled manpower	0.67	12
23. Weather conditions	0.433	21
24. Material approval	0.73	9
25. Construction errors at jobsite	0.63	13
26. Poorly written contract agreement document between owner and designer	0.833	4
27. Inappropriate selection of construction materials by designer	0.58	16
28. Owner's low budget for design services relative to requirements	0.6	15
29. Design changes by the owner	0.8	6
30. Slowness of owner's acceptance of final design	0.53	18
31. Inaccurate estimation of project cost by designer	0.7	10
32. Insufficient design communication aids between designer and owner	0.68	11
33. Lack of communication b/w designer and owner's family	0.8	6
34. Designers lack of experience	0.75	8
35. Participants honest wrong belief	0.85	3

10 MOST IMPORTANT FACTORS THAT AFFECTS DESIGN-CONSTRUCTION INTERFACE

35 factors were selected for this study. Out of these 10 most important factors that affects design-construction interface is described below.

1. Design complexity

Complexity affects the flow of construction activities. Complex design can lead to loss of productivity. Here the respondents are designers.

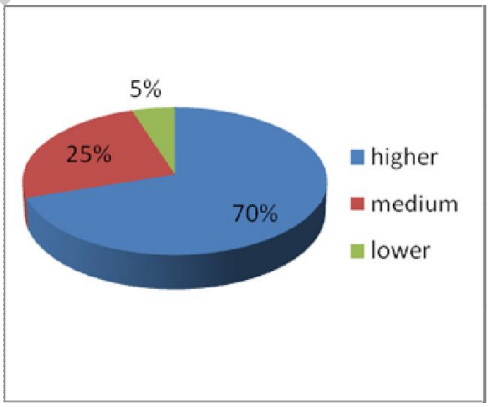

Fig 1 Design complexity

From fig 1 it can be concluded that 70% of the respondents accepted that design complexity is a major factor that affects design-construction interface.

2. Time limitation in design phase

Time limitation may occasionally force the designer to wrap up the necessary design works at a lower quality.

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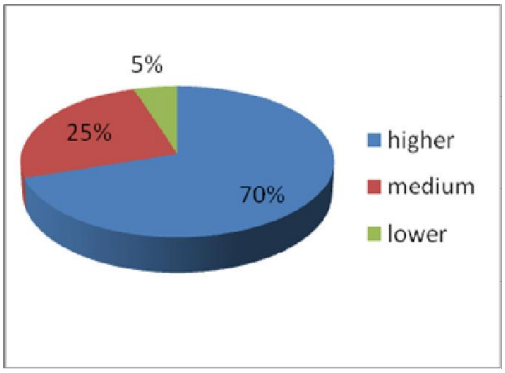

Fig 2 Time limitation in design phase

From fig 2 it can be concluded that 70% of the respondents agreed that time limitation in design phase affects construction industry.

3. Lack of accuracy in specification and working drawings

If the working drawings or the specifications are incomplete or unclear, it will create problems in their interpretation between the contractor and the owner and cause delay in construction.

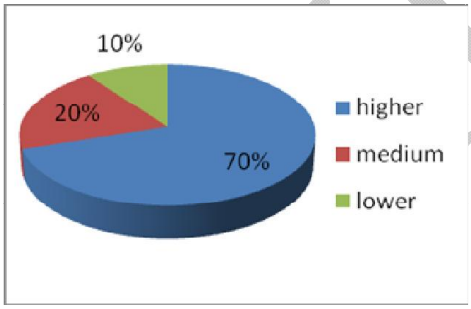

Fig 3 Lack of accuracy in specification and working drawings

Fig 3 states that 70% of the respondents accepted that lack of accuracy in specification and working drawings affects construction.

4. Lack of communication between designer and owner's family

If the actual family design requirements are not incorporated in the design, the approval of the final design will be delayed and also more modification of the design may be required. Here respondents are designers.

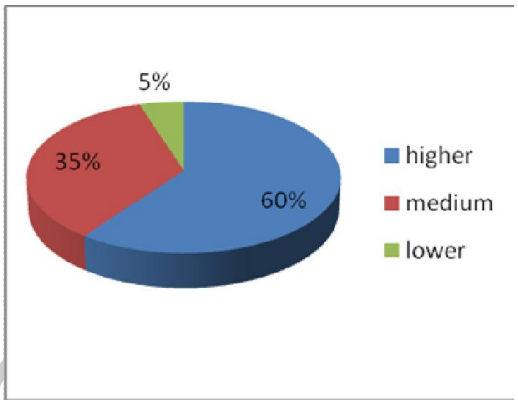

Fig 4 Lack of communication between designer and owner's family

From fig 4 it is clear that 60% of the participants agreed to this statement. Only 5% of them considered lack of communication between designer and owner's family as a lower factor.

5. Participant's honest wrong belief

Participant's honest wrong beliefs may cause construction professionals to contribute poor value add in projects.

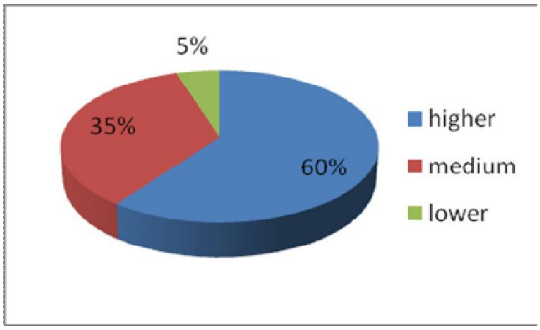

Fig 5 Participant's honest wrong belief

Fig 5 states that 60% of the respondents accepted that participant's honest wrong belief is a higher factor that

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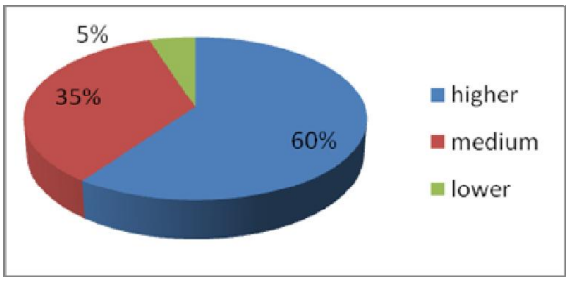
affects design-construction interface. 0nly 5% of them responded that it is a lower factor.

6. Design complexity

Complexity may cause problems at project interfaces. Here the respondents



are contractors.

Fig 6 Design complexity

From Fig 6 it can be concluded that 60% of the participants accepted that design complexity is a higher factor that affects design-construction interface

7. Poorly written contract agreement document between owner and designer

A contract is written to prevent any unlawful act and it refers to all records in connection with the work at any specific time.

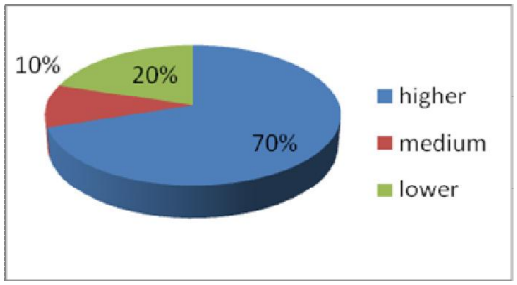
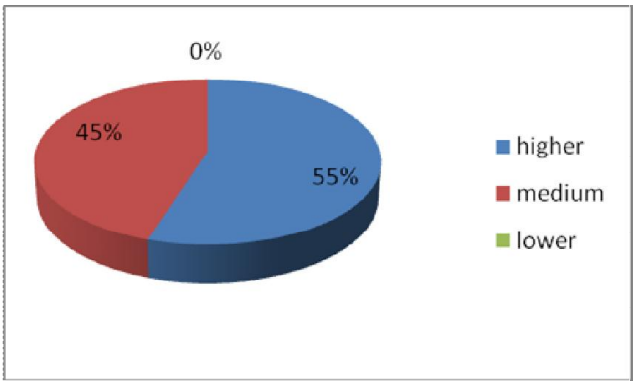


Fig 7 Poor agreements

Fig 7 states that 70% of the respondents accepted that poor agreement is a major factor that affects design-construction interface.

8. Lack of human resources in design firm



Quality work and timely schedule would be affected in the absence of adequate manpower support.

Fig 8 Lack of human resources in design firm

Fig 8 states that 55% of the respondents accepted that lack of human resource in design firm is a higher factor that affects design-construction interface.

9. Owner's desire to modify the use of space after design process

This problem only arises when the owner needs to add, delete or modify the original plans and specifications

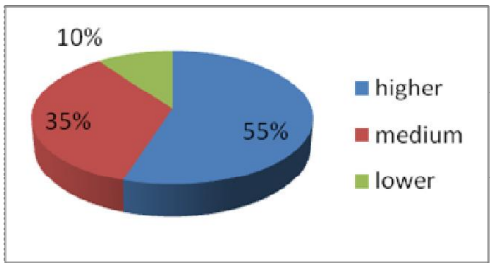


Fig 9 Owner's desire to modify the use of space after design process

Fig 9 states that 55% of the respondents agreed that owner's desire to modify the use of space after design process affects construction process.

10. Shortage of construction materials

The shortage of materials may change the design to accommodate the new materials used as the replacement.

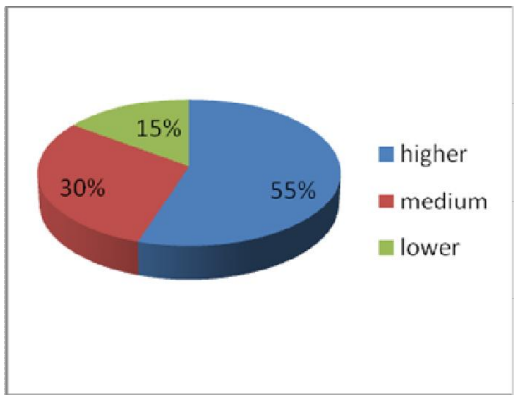


Fig 10 Shortage of construction materials

From the fig 10 it can be concluded that 55% of the respondents accepted that shortage of materials is a higher factor that affects construction process.

CONCLUSIONS AND SUGGESTIONS

The main objective of the thesis was to determine the factors affecting design-construction interface, to know their causes on construction works and to identify ways of preventing or solving these problems. 35 major factors contributing design-construction interface problems were selected for the study. For collecting the data for this project, 30 companies were selected. 20 companies responded to the direct interviews and on-line surveys. Method used for analysis of data is relative importance index. From the analysis & results 35 factors are ranked according to their Relative Importance Index value.

From the study most important sources of problems at the design-construction interface are design complexity, time limitation in the design phase, lack of accuracy in specification and working drawings, lack of communication between designer and owner's family & participants' honest wrong beliefs. And the least important sources of problems at the design-construction interface are weather conditions, involvement of the contractor in the design conceptual phase, involvement of the contractor in the design development phase. These problems produce a series of impacts in the construction works such as: delays in construction, rework, conflicts between professionals etc.

Time limitation in the design phase is one of the most important factors. If adequate time is not given, the design cannot be developed in proper way and may result in misunderstandings between professionals working on project. Therefore allocating adequate time for the design phase would help in eliminating the design discrepancies. Lack of accuracy in specification & working drawings is another most important factor that affects design-construction interface. It can be eliminated by providing guideline standards for stipulated drawings. By conducting frequent professional meetings during the various project phases can reduce gap between the contractor and the designer at the project interface. This can also help in eliminating problems that may be caused because of the honest wrong beliefs of the participants.

Regular safety meetings and preconstruction exercise done prior to any construction activity can reduce the severity of these problems. The project construction management team should also work hard for reducing these problems. They should be strictly professional in maintaining the stipulated time schedule of the client. There may arise many conflicts during the construction phase but as a construction management team shall be well planned enough to battle out these conflicts without hurting the client.

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