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Intra-Communication Analysis of Design Team in Construction Projects

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Abstract- In recent years growing the complication and specialization of the large projects in construction industry has resulted in wide recruitment of specialty teams in different phases of the projects. All these has lead into more emphasis on team works and maintaining coordination between various sections, which in turn guarantees the overall performance of a project. In many construction projects, design changes cause unexpected deviations from the client objectives therefore design team has an important role in successful project delivery. The purpose of this paper is to investigate the impact that integration can have on teamwork effectiveness within construction project design teams. It also wants to investigate the communication between the teams' members and determine the important member of that in different phase of the project by visualizing its network and analysis it with Social Network Analysis (SNA).

Index Terms—*Design Team, Intra-Communication, Social Network Analysis, Team work*

I. INTRODUCTION

In many construction projects, design changes cause unexpected deviations from the client objectives. Project teams currently often find it difficult to identify in advance what the impact of a proposed change will be. [1]

The implementation of changes in construction projects often causes deviations from client objectives such as the cost of the project, the date of completion and the performance requirements[2] [3]. This is a world-wide problem, observed in surveys conducted in different places [1] to name a few.

Design is a complex process that continues to grow in complexity because of the dramatic increase in specialist knowledge. There are now many contributors to the design of a project from a wide variety of organizations. This gives rise to design processes that consist of a continual exchange and refinement of information and knowledge. Even the most experienced design teams can fail to manage this complex process and supply information at the wrong time and of the wrong quality to members of the production team." [4]

High performance teams achieve outcomes that exceed the expectations of the project and often demonstrate unique or innovative approaches within a final solution. These teams challenge conventional expectations by combining individual strengths and knowledge to generate solutions that exceed the capability of an individual team member. **[5]**

This research use a social network approach to draw design teams network and measure the flow of communication and of knowledge exchange between design team participants.

II. TEAM WORK

A. *Team work importance*

Teamwork is a multi-faceted concept—a rich and deceptively complex term. It has been defined as 'a small number of people with complementary skills who are committed to a common purpose, performance goals and approach, for which they hold themselves mutually accountable. **[6]** Teamwork is also said to be characterised by **[7]**: helpfulness, coordinated effort, a shared approach to working, open communication, and friendliness

Innovation teams vary in terms of team members' proximity, i.e., the degree to which all team members are in direct vicinity over the duration of the project. The proximity of team members, however, has potentially important implications for the collaborative working of teams.

In teams with high teamwork quality, team members openly communicate relevant information, coordinate their individual activities, ensure that all team members can contribute their knowledge to their full potential, mutually support each other in team discussion and individual task work, establish and maintain work norms of high effort, and foster an adequate level of team cohesion where team members maintain the group. **[8]**

B. *Design teams in construction projects*

Achieving design quality with systematic design management is essential for any construction project. This becomes all the more important and difficult for infrastructure projects which are complex in nature and involves several

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disciplines and multiple stake holders. Normally, the client and the design team including the lead consultant and various specialist sub-consultants work in different places in their respective offices, which normally result in problems such as poor coordination, lack of collaboration, excessive variations, design changes, abortive reworks and unwarranted delays. In traditional design management arrangements, the design teams of different disciplines are working in their own offices at different distributed locations. Such distributed functioning might be more complicated in cases such as joint-ventures, sub-consultancies and outsourcing. **[9]** The concept of team building and principles of integrated design office for collaborative engineering designs are being encouraged to achieve enhanced organizational and individual performance outcomes from various useful measures such as shared focus, synchronous team-working, dynamic interactions, efficient coordination, effective collaboration, integrated resource management, and closer physical/ virtual proximities. **[10]**Such integrated design office arrangement in large/complex projects supports effective design management and best value through (i) increased informal interactions, (ii) enhanced role clarity and understanding, (iii) more frequent communications between relevant parties, (iv) development of harmonious relationships, (v) effective problem solving, (vi) quick/ timely decisions, (vi) enhanced creativity/ innovations. **[9]**

III. DESIGN OF CONSTRUCTION PROJECTS

A. *Design necessities in construction*

The building design teams' efforts are crucially based on a successful interplay between iterative and interdependent processes, actors and actions. [11]A whole range of predictable and unpredictable issues are impacting the design team members' individual and collective efforts. These issues are placed on many levels, from Architecture–Engineering–Construction (AEC) industry level down to the level of the individual designer.

Different trends in the society, as for instance globalization and the increasing focus on sustainability and environmental issues, have contributed to raise the complexity of the design process even more. The interest in integrated practice and collaboration, where specialized participants with different backgrounds, preferences and experiences try to achieve a common goal, is growing within both research and practice.

Construction projects can be divided in three levels based on complexity and importance; a macro-level (overall project), a meso-level (the design team) and a micro-level (the individual practitioner) (Fig. 1). [9]

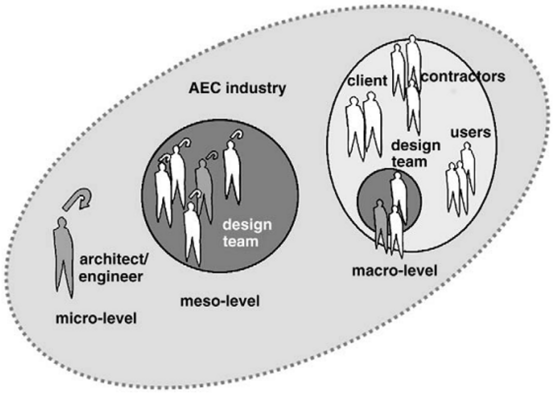

Fig. 1. The three hierarchical project levels, in the construction industry

Architectural design is a knowledge-intensive activity. [12]There is a general consensus that an architect's way of knowing exists in perhaps the oldest recognized design profession [13].For instance, Schon (1983) proposed the concept of reflection-inaction to explain how the design professionals acquire their professional knowledge in their practice. The situation is further complicated by the project-based nature of construction industry. Project as a common organization of construction activities highlights its importance as a context to enable knowledge acquisition and knowledge sharing [13]As architects build up knowledge of examples, images, understandings and actions through their project practice [14]their knowledge sharing behavior will significantly contribute to the performance of their future projects and offer competitive advantage However, an architect in Mainland China said, ‘Several years ago architects focused on cooperation. However, due to the development of a market economy, competition has become more important nowadays.’ (This citation comes from the conversation while the authors conduct exploratory investigation about architectural design project teams.) Both theoretical knowledge and professional experience are their competitive edges. Hence, to maintain their competitive edges, architects in project teams are not always willing to share their knowledge with others [15].

B. *Design challenges in construction*

The dynamic and complex nature of design tasks and the specialized knowledge of team members in design projects make it difficult to control members' behavior, such as knowledge sharing.

Because of the complex context of design process, some challenges and defects could be detected during the project lifecycle such as:

• Change orders—i.e., changes originating with the client, due to omissions in the requirements, changes in the clients' activities, or a better understanding of client needs.

• Rework—i.e., changes originating with the project team, due to errors or solutions which emerge during the development of the design and planning, and the actual construction.

• Changes originating with suppliers, due to changes in

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technology or the inability to meet the original planning targets.

• External causes, such as new regulations. It may seem natural to treat large-scale change orders, which modify the scope of the project, differently from small-scale rework, which affects only a small part of the project. [1]

Also there are other design defects that generally, during the execution phase are detected; the problems associated with the designs are mainly:

1) Poor Design Quality: Design drawings are generally incomplete and they are not explicit, requiring a great amount of specifications. Specifications are difficult to handle and sometimes are ignored. Very often design documents have inconsistencies, errors and omissions, or simply lack of clarity in the presentation. This implies that those that should carry out the work do not have the necessary information or have the wrong information to do the job.

2) Lack of Design Standards: There is a lack of standards in the designs, and lack of suitability for the existing technology. In many projects of similar characteristics, or of the same type, the designs used are completely different with the consequent loss of efficiency in the construction phase.

3) Lack of Constructability: An important proportion of the problems detected during construction is due to lack of constructability of the designs. [16]

IV. Research procedure

A. *Social Network Analysis*

The research approach used in this paper is a social network analysis which analyzes the current state of design team in 2 level of projects which needs design team works; meso-level and macro-level. Social Network Analysis provides a method to understand informal networks within and between organizations and manage the informal networks systematically [17].SNA has been an instrumental tool for researchers focusing on the interactions of groups since the concept was introduced by Moreno in 1934 [5] [18] [19].

The key difference that distinguishes Social Network Analysis from other analysis and management methods is that Social Network Analysis draw attention to informal network in working place. Basically, Social Network Analysis is used to measure and visualize relationships and flows between peoples, groups, organizations, computers or other information/knowledge processing entities. [20]

B. Data Description:

In order to develop inter-firm networks and investigate if they are the collaborated or not, we collected information about collaboration between 2 Iranian consultants with different personnel population and project scale. Concentration of this research is on Collaborative relations between design team members.

C. Overall model and Data analysis:

The information has been collected by filling questionnaire between 21 members of design team in one company in macro-level and 7 members of another team in meso-level. The survey contains questions that map to the levels in the Social Network Model.

The survey results were analyzed using the UCINET Social Network Analysis software. The UCINET software provides the mathematical measurements as well as the graphical representations required for the organization analysis. A separate analysis is completed on each of the variables to acquire the relationships outlined in the Social Network Model. The analysis in this report utilizes three key measurements (Power, Centrality and Betweenness) for evaluating the organization network as follows:

Power – The power variable works in conjunction with centrality. Whereas centrality measures the total number of relationships that an individual may have, power reflects the influence of an individual in the network. Individuals who are giving information to others in the network, who are in turn passing along that information to others, has a high degree of influence or power. Individuals, who are mainly on the receiving end of communications may be central in the network, but have little power as they do not influence the actions taken by others. [19]

Centrality is a structural attribute of nodes in a network, in Social Network Analysis practice; centrality is one of the most important and widely used conceptual tools for analysing social networks. Nearly all empirical studies try to identify the most important actor in a social network model. The centrality measurement is to identify who is the most important actor in a social network model [20]. Centrality denotes the grade of structural efficiency. There are three types of centrality whether the focus is placed on inward directive, outward directive, and total connection: in degree centrality, out degree centrality, and total centrality [17] Equation of that is like following:

- Centrality = (variation in the degree of vertices)/ (maximum degree variation)
-

Betweenness - This variable measures the amount of information that is routed through an individual to distribute to the team. This rating indicates which individuals are involved in discussions that are occurring within the network. [1]

V. Intra-Communication of design teams

For finding the communication Exchange between the companies, we asked some questions about if they know each other and the time of their communication (such as telephone dialog or casual meeting between two companies).In Tables 1 and 2 amount of key measurement of case studies which has been achieved as a SNA result, has been showed, Although it is just showing the total measurements of each team network, but Figures 2 And 3 each node has a different size depend on its Centrality In degree. In Figure 2 the network of design team in meso-level construction project has been shown.

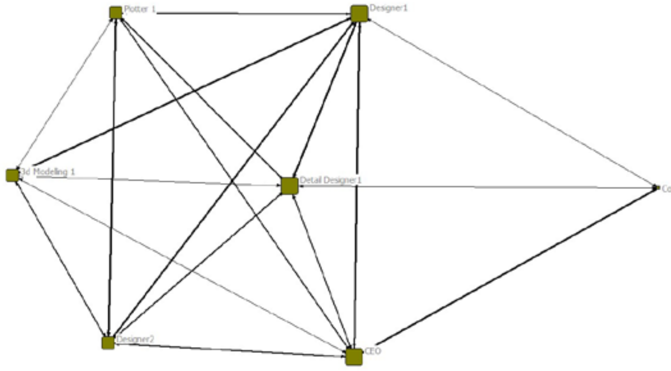

Fig. 2. Design team communication network in meso-level construction project

As it is obvious in Fig. 2 contractor has the less communication and designer 1 and CEO of the consultant have the most communication with other member of the design team. In Table 1 you can see the importance of each member in the team based on their degree of communication with other members.

TABLE 1: MEASURES OF COMMUNICATION OF THE DESIGN TEAM IN MESO-LEVEL CONSTRUCTION

Role of team member	Power	Centrality		Betweenness
		In degree	Out degree	
Designer1	1.212	80	80	25.736
CEO	1.212	70	73.333	30.539
Designer2	1.102	66.667	66.667	17.338
Detail Designer	1.047	56.667	63.333	18.297
3d Modelling	0.826	50	50	9.309
Plotter	0.771	53.333	46.667	11.241
Contractor	0.441	30	26.667	4.150

In Figure 3 the network of design team in macro-level construction project has been shown. As it is obvious in this level of construction, design team is more complex and the network is denser than meso- level network.

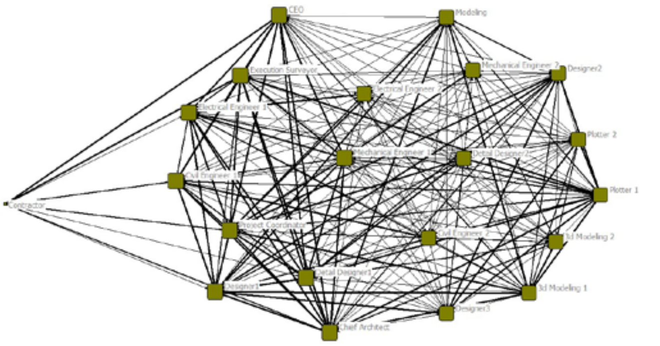

Fig. 3. Design team communication network in macro-level construction project

In Fig. 3 also contractor has the less communication with the member of the design team same as meso-level team but except that the size of other nodes in this network are more similar.

TABLE 2: MEASURES OF COMMUNICATION OF THE DESIGN TEAM IN MACRO-LEVEL CONSTRUCTION

Role of team member	Power	Centrality		Betweenness
		In degree	Out degree	
Project Coordinator	1.494	71	70	8.249
Chief Architect	1.366	64	64	7.292
Detail Designer1	1.259	57	59	5.954
Designer1	1.217	65	57	6.326
Execution Surveyor	1.217	48	57	6.058
3d Modelling1	1.153	47	54	5.61
Electrical Engineer 1	1.110	49	52	6.194
Mechanical Engineer1	1.089	46	51	5.931
CEO	1.089	55	51	6.530
Civil Engineer 1	1.067	51	50	6.116
Plotter 1	1.046	59	49	3.896
Modelling	0.939	37	44	3.896
Designer2	0.896	49	42	4.762
Detail Designer2	0.854	35	40	3.7
Designer3	0.768	38	36	4.347
3d Modelling 2	0.683	27	32	3.255
Plotter2	0.640	39	30	4.401
Civil Engineer2	0.619	26	29	2.959
Mechanical Engineer2	0.576	27	27	3.057
Electrical Engineer 2	0.576	30	27	3.078
Contractor	0.512	25	24	1.339

In Table 2 you can see the importance of each member in the team based on their degree of communication with other members.

VI. RESEARCHER ANALYSIS

As illustrated in Figs. 2 and 3, the visualization technique provides significant opportunity to identify structural concerns within the team network. For example, Fig. 2 illustrates how the project network followed a centralized pattern with the CEO of the consultant controlling most communications related to team decisions. Similarly, Fig. 2 and Fig. 3 illustrates how the contractor became isolated from the design team during the decision-making and design process. It could be the reason of detection of design defect during the execution and not before that. This demonstrates that the current design process is incomplete and chaotic, since it does not allow the persons in charge of the project execution the adequate knowledge of the design and it prevents the interaction among the different specialties involved in the project

The communication rating reflected on the team's ability to communicate during the design process and important decision making about the project. The poor performance in this category could be anticipated based on the betweenness, power, and centrality ratings of the Designer 1 in meso-level and Project coordinator in macro-level assigned to this task.

Specifically, the individual assigned to lead this task was positioned in the network in such a manner that the network was left vulnerable to actions taken by the them, no other team member had the full range of knowledge required to successfully perform the communication task at the competition.

For some field professionals one of the main problems present in the designs are the errors of the designers themselves and the lack of coordination among specialties. Other problems are caused by late changes introduced by the owner and the designers, the inconsistency between drawings and specifications, the lack of construction knowledge of the designers and specifications with little technical content. These defects produce a series of impacts in construction projects such as: delays, manpower losses and inappropriate use of equipment.

The principal problem found in the designs was the lack of information. The designers did not deliver enough information on time to the construction field and to other participants in the design process. This could happen from lack of the coordination between the team members and also low flow of communication and knowledge between them.

As Measure of Table 1 show in meso-level project, small design team could be in charge and CEO the company could also lead the team and it doesn't needs someone for coordination the team. Also design process could perform in hierarchy stage and detail design could start after finishing the architectural design, but in macro-level as illustrated in Table 2 because of project complexity, architects, detail designer, civil engineers and electrical engineers and mechanical engineers and other team member should work at same time and from the first stage of architectural designing, because each changes that happens after completion of the design because of civil or electrical or mechanic problems could cost loss of time and money which could failure the company in macro-level projects. Existence of a person as a team coordinator also is necessary in this level of construction, because these companies could have several projects at the same time and therefore CEO the company could not lead the design teams of all of them, the complexity team and high amounts of team members are another proofs for this claim.

Another Problems that could threat the team work in these teams is trust issues which team member don't exchange knowledge because of company policy or because of competitive environment domains between them. These issues should be solved by the CEO of the Consultant and also team coordinator by specifying the responsibility and role of each member and also by growing the team work spirit in the company.

VII. CONCLUSION

However, it must be noted that significant challenges exist in the macro-level construction First, the construction industry is based on network instability where project participants are regrouped on almost every project with little regard to past network connections. This instability places the network in a scenario where minimum experience exists between the participants and thus forces the network to rebuild a significant portion of the trust relationship in each project. Second, construction networks are often required to move from the formation stage to the collaboration stage very rapidly due to schedule constraints. This leaves little time for the participants to build trust prior to the execution of the project tasks. And finally, the contractual relationships defined in a project context can serve as barriers to the free exchange of knowledge due to liability concerns but in spite all these difficulties for teamwork in construction design, it is inevitable and successful project delivery is not possible without the collaborated team.

It has been cleared that the shape and importance of team changes based on project importance and amount. As project get more complex and bigger, the coordination the design team is also get harder. Identifying the design problems of big construction projects and understanding the form of communication between design team members could help us for better team building in future.

This paper just investigate communication of design team member with other persons of the project and analysis the intra-firm relationships of the design consultants but the inter-firm relationship of different parties of construction project and their communication in the project level is also very important and could be a great field for future researches.

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