5th International/11th Construction Specialty Conference
5e International/11e Conférence spécialisée sur la construction

Vancouver, British Columbia
June 8 to June 10, 2015 / *8 juin au 10 juin 2015*

DEVELOPMENT OF MECHANISMS BY USING CONCEPTUAL SYSTEM DYNAMICS MODELS TO RESOLVE DELAY IN CONSTRUCTION PROJECTS

Diilip Kumar Das
Central University of Technology, Free State, South Africa
ddas@cut.ac.za

Abstract: A major concern in the construction industry remains with the non understanding of the mechanisms that cause delay in construction. Therefore, the objective of the paper is to evolve mechanisms, which could assist in identifying activities and events, comprehend and foresee the causal feedback relations among the variables that cause delay, and take appropriate actions to resolve the challenges of delay. A survey was conducted among 120 stakeholders from various construction projects in India. Evaluation of the major control parameters were done by using Likert scale. Subsequently, conceptual models were developed by using System Dynamics modelling principles. The important causal feedback relations from the conceptual models were used to evolve mechanisms to understand the events and chain of actions that lead to delay; which could assist in evolving policy/strategic interventions to resolve the challenges. It was observed that most of the client, contractor, consultant and design related variables are the major causes of occurrence of delay. However, policy/strategic interventions based on the four dynamic hypotheses; such as, the causal feedback relationships among (1) communication, decision-making, progress in payment and construction delay; (2) effective planning and scheduling, planning for finance and budget ahead, adoption of construction methods, contingencies in planning for rework and exigencies by the contractor and construction delay; (3) appointment of highly competent consultant and design team, delay in producing the design documents and delay in construction; and (4) provision of effective communication mechanism, conflict resolution and delay in construction, would able to assist in resolving delay in construction.

1 INTRODUCTION

Delay is a major cause of concern in almost all construction projects. The reasons of delay could be generally classified under broad issues related to client/owner, contractor, design, construction, materials, equipment and project management (Alaghbari, Razali, Kadir, Ernawat 2007, Assaf, and Al-Hejji 2006, Chan and Kumaraswamy 1997, Desai and Bhatt 2013; Kaming, Olomolaiye, Holt, Harris 1997, Odeh and Battaineh 2002; Stumpf 2000). However, the main concern remains with the non understanding of the mechanisms and not foreseeing of the unwarranted events by the stakeholders and project management team, which lead to delay. Over the years there are plenty of investigations made regarding to the causes, and various methods of analysis of construction delay. But, investigations relating to development of interventions or mechanisms to resolve the challenges of delay in construction projects are observed to be scarce. Taking into account the significant impacts of delay, there is an argument that development of mechanisms by considering various components and stakeholders would assist to foresee the chain of events that cause delay and to resolve the challenges (Alaghbari et al. 2007, Sweis, Sweis, Hammad, Abu 2008). Therefore, the objective of the paper is to evolve mechanisms, which could assist the project stakeholders to identify the activities and events, comprehend and foresee the causal feedback relations among the variables that cause delay, and take appropriate actions to resolve the challenges of delay. The investigation was conducted by using a survey research methodology and System Dynamics (SD) modelling approach. A total of120 stakeholders and professionals from large and medium projects in India, which includes project managers, architects, engineers, skilled technicians, consultants, designers, quantity surveyors, contractors and clients, were surveyed through semi-structured interview method to comprehend the major control variables causing delay in construction projects. Followed by, conceptual models were developed based on the causal feedback relations among the major variables influencing delay by using SD modelling principles. The important causal feedback relations in the conceptual models were used to comprehend the mechanisms that could enable understanding of the events and chain of actions that lead to delay; and to evolve policy/strategic interventions to resolve the challenges. It was observed that variables relating to client, contractor, consultant and design are the major causes of delay. These variables are interlinked with each other and function in causal feedback mechanisms creating a chain of actions, which influence the occurrence of delay. The mechanisms developed based on these causal feedback relations among the variables will act as a tool to assist the stakeholders, such as clients, contractors, consultants and project management team to foresee the challenges of delay ahead at each and every stage of construction projects and take appropriate actions to resolve them.

2 LITERATURE REVIEW

Delay in construction can be defined as the time overruns either beyond the contract date specified in a contract, or beyond the date that the parties agreed upon for delivery of a project. Generally, it is the additional days of work for completion of project/ activity or as a delayed start of an activity (Assaf, Al-Hejji 2006; Stumpf 2000). Since the construction process is subject to many variables and unpredictable factors, delays are found to be inevitable and become integral part of the project's construction life. Even with the availability of advanced technology, and understanding of the project management techniques, construction projects continue to suffer delays (Stumpf 2000).The sources of delay are varied, which include the performance and involvement of stakeholders, resources availability, environmental conditions, contractual relations, and so on (Alaghbari, Razali, Kadir, Ernawat 2007, Kaming, Olomolaiye, Holt, Harris 1997, Odeh and Battaineh 2002, Stumpf 2000). Besides, scholars like Al-Barak (1993), Al-Momani (2000), Chan and Kumaraswamy (1997), Kaming et al. (1997), Kumaraswamy and Chan (1998) and Noulmanee, Wachirathamrojn, Tantichattanont, Sittivijan (1999) have studied the causes of delay in different projects.

From these studies it is found that causes of delay vary with context and project environment. For instance, Chan and Kumaraswamy (1997) found five principal factors: poor risk management and supervision, unforeseen site conditions, slow decision making, client-initiated variations, and work variations. According to Kaming, et al. (1997) two different set of factors influence differently for cost overruns and time overruns. The major factors influencing cost overrun are material cost increase due to inflation, inaccurate material estimation and degree of complexity. For time overrun, the most important factors responsible are design changes, poor labour productivity, inadequate planning, and resource shortages. Some attribute the reason to bias of different industry groups and difference in perception by different groups as to what causes delay (Kumaraswamy and Chan 1998). According to Noulmanee et al. (1999), although delays can be caused by all parties involved in projects, the main causes come from the inadequacy of sub-contractors, organization that lacks sufficient resources, incomplete and unclear drawings, deficiencies of consultants and contractors, and differences between consultants and contractors. Similarly, Al-Momani (2000) observed that delay is related to designer, user changes, weather, site conditions, late deliveries, economic conditions and increase in quantity. Al-Barak (2000) concluded that lack of experience, poor estimation practices, bad decisions in regulating company's policy, and national slump in the economy are the severe factors, which cause delay. Also, Aswathi and Thomas (2013) observed that contractors, rather than consultants and owners, were the most responsible party for the delays in construction projects (Ndekugri, Braimah and Gameson 2007). However, the role of owners in causing delay is no way meagre. In summary, factors like delay in progress of payments by owner, delay to furnish and deliver the site to the contractor by owner, change orders by owner during construction, late in revising and approving design documents by owner, delay in approving shop drawings and sample materials, poor communication and coordination by owner and other parties, slowness in decision making process by owner, unavailability of incentives for contractor for finishing ahead of schedule, suspension of work by owner cause delay (Desai, Bhatt 2013, Assaf, Al-Hejji 2006). Similarly, inappropriate design, design changes, mistakes in design, late inspection, late design works, late approval, insufficient inspectors, incapable inspectors could cause delay (Alhomidan 2013, Desai and Bhatt 2013). However, causes like accidents, temporary stoppage, rework, extra work, external factors like weather conditions, unavailability of utilities, government law and regulations, etc., cannot be undermined (Iyer, Chaphalkar, Joshi 2008). Overall, the attributes can be classified into project, owner, contractor, consultant, design, material, equipment, labour and external related factors. Although, it is seen that many of the factors are interlinked and have cause and effect relationships (Assaf and Al-Hejji 2006, Chan and Kumaraswamy 1997, Frimpong et al. 2003, Manavizha and Adhikarib,2002, Odeh and Battaineh 2002, Sambasivan and Soon 2007), studies relating to such aspects are found to be limited. So, scholars like Alaghbari et al. (2007) stressed the importance of early identification of construction delays and development of major delay-reducing remedies (Sweis, Sweis, Hammad, Abu 2008).

A number of methods and techniques have been developed over the years to understand or analyse delay in construction industry (Braimah 2013). Yeats (2007) developed a decision support system (DAS) for delay analysis in construction projects, which could consider factors like equipment, external delay, labour, material, owner, contractor, management, subcontractor and weather (Odeh, Battaineh, 2002). Terry (2003) studied the standard methods currently available for assessing extension of time delays on major projects, and issues around such assessment, and used network causal mapping and system dynamics approach to study the impact of delays on a project. The other methods used are the frequency index (FI), severity index (SI), importance weight (IW), importance index (II), average weight (AW), influence value and activity duration. Some of the investigations have also used Monte Carlo simulation to derive delay reduction interventions (Aswath, Thomas 2013) and Fuzzy logic for delay computations (Pandey, Dandotiya, Trivedi, Bhadoriya, Ramasesh 2012). However, many of these methods do not explicitly consider the causal feedback relationships among the factors, which cause delay.

3 METHODOLOGY

A survey research methodology was employed to collect primary data from the various stakeholders in construction projects in India. A total of 120 questionnaires were administered, of which 102 were returned (approximately 85% response rate). Professionals and stakeholders from large and medium projects in India, which includes project managers, architects, engineers, skilled technicians, consultants, designers, quantity surveyors, contractors and clients/owners, were surveyed through semi-structured interview method. The respondents were asked to provide their opinions on the various parameters that cause delay and to rate the challenges in a scale of 1 to 5 (1= not influential, 2 = less influential, 3 = somewhat influential, 4 = significantly influential and 5 = most influential in causing delay) from the experiences in the projects they were involved in. The simple random sampling technique was used in the selection of samples for the survey.

Quantitative descriptive statistics analysis and Cronbach's alpha test of the data collected were conducted to observe the reliability of the data. Likert scale (Gravetter and Wallnau 2008) was employed to measure the relative influence causing delay through development of a delay index (DI) for the variables; and their general rank and rank under each major factor. Followed by, conceptual models by using SD modelling principles based on the systems thinking process (Von Bertalanffy 1974) were developed. The construction project was considered as the system or environment while developing the model.The influential variables, their positive and negative influences on the related variables and the causal relationships among them were used to develop the conceptual SD models. The causal relationships among the variables within and across the major parameters were developed based on the discussions and experiences of the professionals surveyed. While developing the causal relationships, initially the variables, such as, information, decision and action and environment (system) variables (Olaya 2012) were identified. The variables were then connected with simple one way causality in terms of one way linkages of information – decisions – actions – impact on the environment with their influence (i.e., information assisting in evolving decisions (policy interventions), decisions leading to appropriate actions, and actions influencing the environment (system)) (El Halabi, Doolan, Cardew-Hall 2012, Veniix1996). Once the one way causalities were established the feedback relationships were checked and established. The constructed causal feedback relations were then discussed with the professional and experts in the field to check the veracity of the causal diagrams and relevant modifications with respect to the variable names, their polarity and causal relations as need be were made. The valid causal feedback diagrams (causal loop diagrams) were then employed to develop the conceptual SD models.

4 RESULTS, CONCEPTUAL SD MODELS AND DISCUSSION

4.1 Major Factors Causing Construction Delay

Table 1 presents the factors and their level of influence in construction delay. The various factors were grouped under project, client/owner, contractor, consultant, design, materials, equipment and labour related factors. However, external factors, such as, weather, availability of basic utilities, regulations, accidents, etc., have been kept out of the scope of the analysis. The acceptable standard deviation (SD) values and high Chronbach α (0.93) value show the reliability and acceptability of the data. The delay index (DI) and their general rankings revealed that majority of the factors belonging to client, contractor and consultant and design aspects of the projects have significantly higher delay indices compared to the factors belonging to materials, equipment and labour aspects. Thus, client/owner, contractor, consultant and design aspects have significant influence on construction delay. Similarly, the ranking in the groups show that delay in progress of payments by owner, slowness in decision making process by owner, change orders by owner during construction, poor communication and coordination by owner and other parties, delay in approving shop drawings and sample materials by the owner are the major client/owner related factors, which cause delay. Factors like delay in furnishing and delivering the site to contractor, suspension of work and lack of incentives to contactors for completion of the work ahead of schedule have lower impact. Similarly, difficulties in financing project by contractor, delay in financing project by contractor, conflicts between contractor and other parties (consultant and owner), rework due to errors during construction, ineffective planning and scheduling of project by contractor are the major contractor related causes of delay. Factors like poor communication and coordination by contractor with other parties, improper construction methods implemented by contractor, and delay in site mobilization also influence delay although to a lesser extent. Under consultant related factors, late in reviewing and approving design documents, delay in performing inspection and testing, delay in approving major changes in the scope of work, poor communication/coordination between consultant and other parties, inflexibility of consultant are the significant causes of delay, whereas delays in producing design documents, complexity of project design, mistakes and discrepancies in design documents, and unclear and inadequate details in drawings are the design related factors, which are the causes of concern. However, despite being relatively less influential delay due to delivery of material and late procurement of material, shortage of equipment, equipment breakdown, shortage of labour and unqualified labour force do cause delay in construction although they can be attributed to contactor or client related factors.

Table 1: Significance of elements and factors influencing delay in construction

Group	Factors	Delay Index (DI) (Mean Score in Likert scale)	SD	Rank in the group	General Rank across the groups
Project	Original contract duration is too short	3.32	0.23	2	17
	Legal disputes between various parties	2.79	0.17	3	22
	Ineffective delay penalties	3.45	0.31	1	15
Client/ Owner	Delay in progress payments by owner	4.35	0.34	1	1
	Delay to furnish and deliver the site to the contractor by the owner	3.65	0.27	7	13
	Change orders by owner during construction	4.10	0.32	3	5
	Late in revising and approving design documents by owner	3.95	0.33	5	7

	Delay in approving shop drawings and sample materials	3.85	0.38	6	9
	Poor communication and coordination by owner and other parties	4.05	0.35	4	6
	Slowness in decision making process by owner	4.20	0.32	2	3
	Unavailability of incentives for contractor for finishing ahead of schedule	2.85	0.26	9	21
	Suspension of work by owner	3.20	0.22	8	19
Contractor	Difficulties in financing project by contractor	4.25	0.36	1	2
	Rework due to errors during construction	4.10	0.32	3	5
	Conflicts between contractor and other parties (consultant and owner)	3.70	0.28	5	12
	Poor site management and supervision by contractor	3.20	0.28	9	19
	Poor communication and coordination by contractor with other parties	3.65	0.31	6	13
	Ineffective planning and scheduling of project by contractor	3.90	0.33	4	8
	Improper construction methods implemented by contractor	3.45	0.26	8	15
	Delay in site mobilization	3.60	0.34	7	14
	Delay in financing project by contractor	4.15	0.38	2	4
Consultant	Delay in performing inspection and testing by consultant	3.85	0.34	3	9
	Delay in approving major changes in the scope of work by consultant	3.95	0.31	2	7
	Inflexibility (rigidity) of consultant	3.25	0.25	6	18
	Poor communication/coordination between consultant and other parties	3.80	0.28	4	10
	Late in reviewing and approving design documents by consultant	4.10	0.32	1	5
	Conflicts between consultant and design engineer	3.20	0.22	7	19
	Inadequate experience of consultant	3.65	0.25	5	13
Design	Mistakes and discrepancies in design documents	4.15	0.35	3	4
	Delays in producing design documents	4.20	0.38	2	3
	Unclear and inadequate details in drawings	4.25	0.39	1	2
	Complexity of project design	4.10	0.29	4	5
	Insufficient data collection and survey before design	3.75	0.25	5	11
	Misunderstanding of owner's requirements by design engineer	3.60	0.24	6	14
Materials	Changes in material types and specifications during construction	3.60	0.27	3	14
	Delay in material delivery	3.90	0.30	1	8
	Damage of sorted material while they are needed urgently	2.60	0.21	5	23
	Delay in manufacturing special building materials	3.10	0.27	4	20
	Late procurement of materials	3.85	0.30	2	9
	Late in selection appropriate materials due to availability of many types	2.45	0.19	6	25
Equipment	Equipment breakdowns	3.45	0.25	2	15
	Shortage of equipment	3.75	0.27	1	11

	Low level of equipment-operator’s skill	3.20	0.24	4	19
	Low productivity and efficiency of equipment	3.40	0.27	3	16
Labour	Shortage of labours	3.80	0.30	1	10
	Unqualified workforce	3.75	0.30	2	11
	Low productivity level of labours	3.45	0.28	3	15

Chronbach’s α = 0.93

4.2 Conceptual Model and Mechanisms

Considering the influence of the factors as discussed above conceptual SD models have been developed to comprehend the dynamic causal feedback relationships among the factors, which cause delay and develop the possible mechanisms that can assist in reducing the delay. In the model, the causal feedback relations (loops), which essentially balance or disrupts the system (construction projects), and consequently augment delay are identified by balancing loops (B). On the other hand, the causal feedback loops, which reinforce the smooth functioning of the system and consequently assist in reducing or eliminating delay, are identified by reinforcing loops (R). While developing the models, only client, contractor, consultant and design aspects were considered because of their higher influence. Consultant and design related factors were taken together because of their strong inter-linkage and interdependence. The other factors belonging to materials, equipment and labour aspects were integrated to the client, contractor and consultant and design aspects according to their relationship and importance.

4.2.1 Client Related Aspects

As mentioned above delay in progress of payments by owner, slowness in decision making process by owner, change orders by owner during construction, poor communication and coordination by owner and other parties, and delay in approving shop drawings and sample materials by the client are the major client/owner related factors, which cause delay although others factors contributes to lesser extent. It is observed that there exists cause and effect relationships among these factors, and they work through a feedback mechanism. Figure 1 manifests the conceptual SD model based on such causal feedback relationships. As shown in the figure, slowness in decision making leads to delay in progress in payment, which cause delay and disrupts the system through balancing loop OB1. Also, poor communication leads to slowness in decision making and vice versa through another balancing causal feedback sub loop OB1A. So balancing sub loop OB1A aggravates the balancing loop OB1. Besides, factors like change in orders during construction, delay in approving the drawing and materials, late approval of revision of designs and delay in furnishing the site delivery by the client are influenced by slowness in decision making and vice versa. On the other hand, effective communication among stakeholders (which can be enhanced by coordination among them) will assist in decision making that will facilitate timely payment and consequently will assist in reducing the construction delay from client’s side.

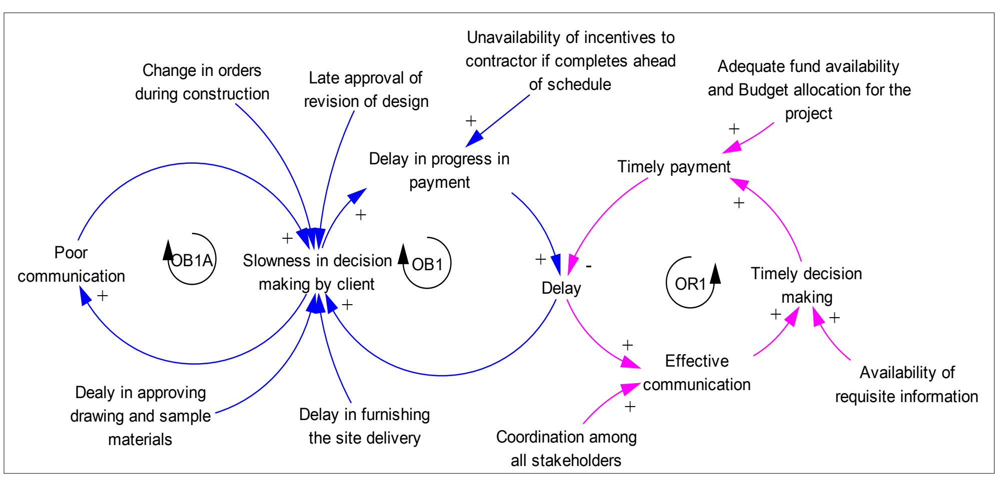

Figure 1: SD model based on causal feedback relations among the for client related factors causing delay

However, to achieve this, measures, such as, coordination among stakeholder that would lead to effective communication; availability of requisite information to aid timely decision making, and availability of adequate fund and budget allocation that would allow timely payment are necessary.

Thus, the feedback mechanism involving effective communication, timely decision making and timely payment will reinforce reduction in delay through reinforcing loop OR1. As a result, the disrupting effects of feedback mechanisms (OB1 and OB1A) are balanced or negated by feedback mechanism OR1. So, the causal feedback relationship among communication, decision-making, progress in payment and construction delay is the dynamic hypotheses, which influence delay and need to be attended to alleviate the problem.

4.2.2 Contractor Related Aspects

Contractors form important parts of construction project. They are essentially responsible for the actual construction activities. As evident from this investigation, difficulties in financing project by contractor, delay in financing project by contractor, conflicts between contractor and other parties (consultant and owner), rework due to errors during construction, and ineffective planning and scheduling of project by contractor are the major contractor related causes of delay. However, factors like poor communication and coordination by contractor with other parties, improper construction methods, and delay in site mobilization also influence delay although to a lesser extent. The causal feedback relationships among the factors and delay in the SD model (Figure 2) reveal that ineffective planning and scheduling has a direct linkage with construction delay through a feedback mechanism (balancing loop CB1). While ineffective planning, essentially may happen because of poor communication, it can influence the construction activities through delay in site mobilization, poor management of site and supervision, and rework because of lack of contingencies in time schedule for such occurrences. Similarly, difficulty in financing the project by contactor, which can lead to delay in financing the project will cause construction delay through feedback mechanism (CB2) and disrupts the project. However, adoption of best practices of the industry through (1) planning for finance and budget ahead (CR1A), which can lessen the burden of difficulty in financing; (2) provision of effective communication and coordination, which can reduce ineffective planning and scheduling (CR1B); (3) use of appropriate construction methods (CR1C); and (4) provision for rework and exigencies (CR1D), which can reduce the rework, will enable reduction of delay in construction.

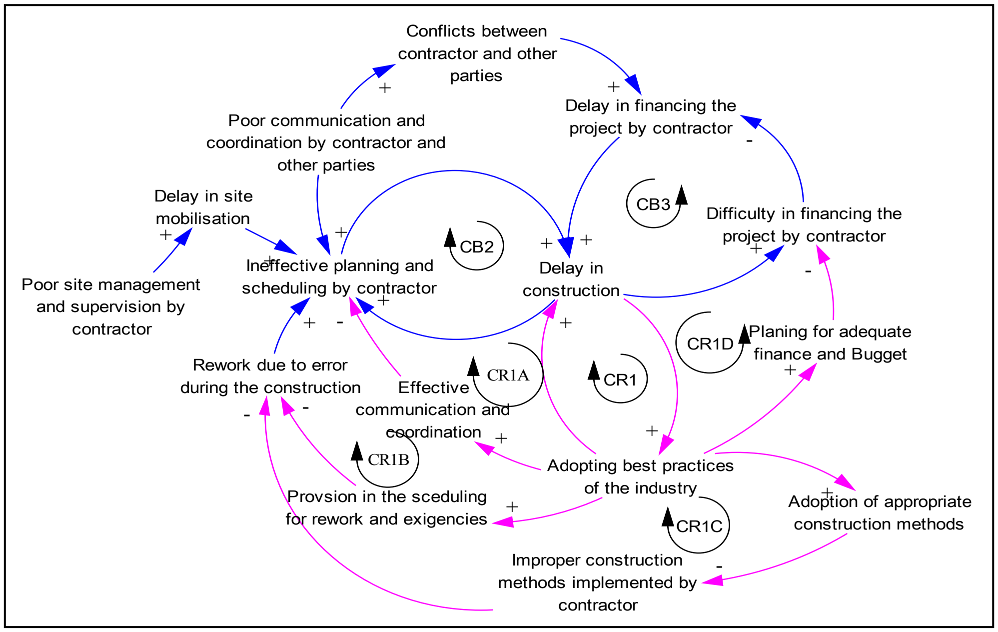

Figure 2: SD model based on causal feedback relations among the contractor related factors causing delay

Therefore, reduction of delay will occur through reinforcing loop CR1 between adoption of best practices and construction delay (through reinforcing sub loops CR1A, CR1B, CR1C, and CR1D). Thus, the disruptive mechanisms through CB1 and CB2 can be balanced or negated by reinforcing mechanism CR1. Therefore, causal feedback mechanism involving effective planning and scheduling, planning for finance and budget ahead, adoption of construction methods, and contingencies in planning for rework and exigencies by the contractor and construction delay is the dynamic hypothesis, which should be considered while developing policy interventions to reduce delay in construction.

4.2.3 Consultant and Design Related Issues

The consultant and design related issues are more or less integrated, and therefore both of them are considered together while developing the conceptual model. As seen from the Table 1, late in reviewing and approving design documents by consultant, delay in performing inspection and testing by consultant, delay in approving major changes in the scope of work by consultant, poor communication/coordination between consultant and other parties, inflexibility (rigidity) of consultant are the significant causes of delay, whereas delay in producing design documents, complexity of project design, mistakes and discrepancies in design documents unclear and inadequate details in drawings are the design related causes, which are responsible for delay in construction. The conceptual SD model is presented in Figure 3. The causal feedback mechanisms manifest that complexity of the project influence the delay in production of the design document by consultant, which essentially cause construction delay through balancing loop DB1. Complexity in design also can lead to mistakes and discrepancies in design document, which can lead to unclear and inadequate detail drawings through balancing sub loop DB1A. Similarly, delay in production of design document is influenced by delay in performing inspection and testing by consultant, delay in approving major changes in the scope of work of the consultant by the client, and late reviewing and approving the document by the consultant. Therefore, complexity of design can disrupt or cause construction delay through balancing feedback mechanism DB1 supported by feedback loop DB1A. However, on the other hand, appointment of highly competent consultant and design team will able to meet the challenges of complex design as well as eliminate the problems of mistakes and errors and enhance clarity in detail drawings through feedback mechanism (sub loop DR1A). Consequently, it will reinforce the reduction of delay by reducing the delay in producing the design documents through feedback mechanism DR1.

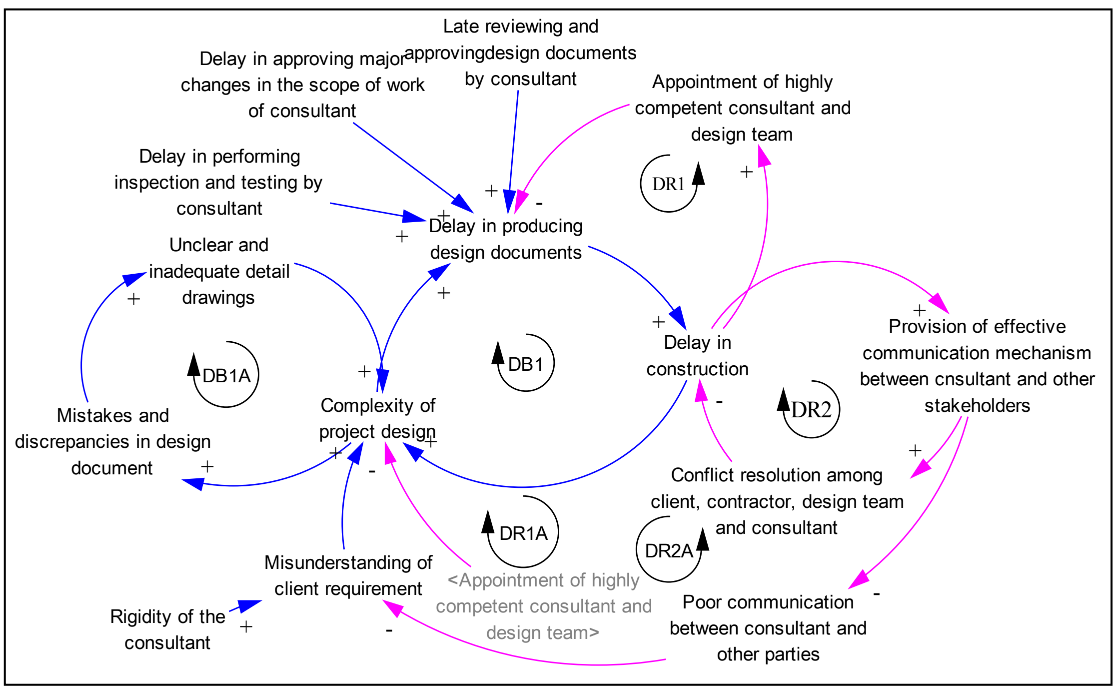

Figure 3: SD model based on causal feedback relations among the consultant and design related factors causing delay

Thus, causal feedback mechanism DR1A reinforces causal feedback mechanism DR1. Further, provision of an effective communication mechanism between consultant and other stakeholders will assist in conflict resolution among client, contractor, design team and consultant, and thereby reduces delay through causal feedback mechanism DR2. Besides, DR2 will be further reinforced by feedback mechanism DR2A, as effective communication will eradicate the challenges created by poor communication like misunderstanding of client's requirement leading to reduction in the challenges of complexity of design. Thus, the feedback mechanism DB1 causing construction delay will be balanced or negated by the feedback mechanisms DR1 and DR2. So, the causal feedback mechanisms involving appointment of highly competent consultant and design team, delay in producing the design documents and delay in construction; and provision of effective communication mechanism, conflict resolution and delay in construction are the dynamic hypotheses, which need to consider while developing policy interventions for reducing delay from consultant and design point of view.

5 CONCLUSION

Delay in construction projects is a menace. It leads to both appreciable cost and time overruns, which affect both socially and economically to the society. Although, there were plenty of studies conducted to investigate the causes of the delay, which differ depending on contexts, yet there are several causes which are observed to be common in most of the projects. However, there is scanty literature available regarding the mechanisms, which could aid in developing policy interventions to reduce or eliminate construction delay. This challenge has therefore warranted the investigation. The investigation was conducted by using a survey research methodology. A survey was conducted among the various stakeholders and professionals belonging to medium and major projects in India to understand the various causes, their level of influence and causal relations. Followed by, causal feedback mechanisms and consequent conceptual SD models were developed by using SD modelling principles, which lead to evolving of dynamic hypotheses to resolve the challenges of delay in construction.

It is evident from the results that parameters belonging to client/ owner, contractor, consultant and design aspects have major influence on the occurrence delay, whereas material, equipment and labour related issues have lesser significance. However, the causal feedback mechanisms revealed that there are four dynamic hypotheses, which need to be considered while developing policy interventions to resolve the challenges of delay in construction. They are (1) the causal feedback relationship among communication, decision-making, progress in payment and construction delay; (2) the causal feedback mechanism involving effective planning and scheduling, planning for finance and budget ahead, adoption of construction methods, contingencies in planning for rework and exigencies by the contractor and construction delay; (3) the causal feedback mechanisms involving appointment of highly competent consultant and design team, delay in producing the design documents and delay in construction; and (4) the provision of effective communication mechanism, conflict resolution and delay in construction.

The paper has its limitations. The obvious limitation is that the modelling was done conceptually, although the basic premise behind it was to see the challenges of delay in a more critical way. However, there is a need for the quantitative modelling to examine the extent to which construction delay can be reduced or eliminated under different scenarios of strategic/policy interventions based on the dynamic hypotheses, which is the further scope of this research. Despite the limitation, this study can assist construction project managers, leaders and stakeholders to analyse and diagnose construction delay challenges by using the dynamic hypotheses in their projects and derive plausible strategic/ policy interventions to reduce or eliminate delay in construction projects.

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