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RESOLVING CONTRACTOR COMMITMENT CHALLENGES IN PROJECT DELIVERY BY USING CONCETPUAL SYSTEM DYNAMICS MODELS

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Abstract

Contractors play a vital role in construction projects. However, their lack of commitment is argued to be one of the major barriers against successful project delivery. This investigation was aimed at to explore how contractor commitment challenges can be resolved to improve their performance in the project delivery. A survey research method was used to collect data, and Likert scale was applied to evaluate the relative importance of the contractor commitment challenges. Followed by conceptual System Dynamics (SD) modelling principle was used to develop causal feedback relationships among the variables influencing contractor commitment and to develop mechanisms to resolve the challenges. Findings suggest that lack of experience, skill, inadequate supervision, and lack of control over the subcontractors lead to contractor's inefficiency. Poor planning and scheduling, poor professional management, poor execution of projects, ineffective/outdated equipment, and inefficiency of labour force result in poor quality of work and delay. In addition, design and documentation challenges disrupt the contractors' schedule. The interlinkage among these variables hinders contractor commitment. However, policy/strategic interventions based on the causal feedback relationships among contractor efficiency, and (1) capacity building; (2) professional management; (3) construction methods; and (4) involvement of the contractor and client in the design process would enable the contractors to overcome their challenges to meet their commitment and improve efficiency in project delivery.

Keywords: Contractor, Commitment, Delay, Performance, Project, System Dynamics

1 INTRODUCTION

Performance of participants on a contract is important for its successful delivery. It is an indication of competency, measure of productivity and quality levels of the project. Contractors' are crucial participants' of a contract and they play significant roles in successful project delivery. Their commitment through signing and accepting a contract form a vital stepping stone for project delivery within scheduled time and resources. In other words contractor commitment is a pledge, which makes contractors to deliver the projects successfully relative to key performance criteria. In this context a number of contractor related attributes such as availability resources, skill and competency, attitude, experience essential assist the contractors to successfully honour their commitments. Although, it is of interest to all parties in a contract that a

project is delivered within the initial stipulated time, cost and specifications, there is always certain amount of risk that remains inherent in the award of construction of a project to a contractor notwithstanding the availability of various attributes such as positive attitudes, ability and experiences because of the commitment variability on account of emergence specific scenarios and context. There are several uncontrollable factors that influence project delivery time. These factors although can be broadly attributed to client related factors, contractor related factors, consultant and design related factors, material and equipment related factors (Al-Moumani, 2000; Andawei, 2002; Dainty et al. 2002; Odeh and Battaineh, 2002; Lim and Ling, 2002; Frimpong et al. 2003; Fox, Marsh, and Cockerham, 2003; Griffith and Watson, 2004; Mbamali, Aiyetan, and Kehinde, 2005; Tam and Tam, 2006; Sambasivan and Soon, 2007; Doloi, 2009a), some of these factors independently or in combination can directly or indirectly impact contractors' attributes influencing their commitments. The adverse impacts of the cause and effect relationships of these factors influencing contractors' commitment consequently, cause delay in successful realisation of the projects and make cost overruns. Therefore, it is essential to identify these factors, understand their causal feedback relationship and mechanisms to resolve contractor commitment challenges in projects. Thus, the objectives of the investigation are (1) to identify the relative influence of the various factors that adversely impact contactor commitments in a project, (2) explore causal feedback relationships among the major influential factors hampering contractor commitment and (3) develop regenerative mechanisms to resolve the contractor commitment challenges. For this purpose a survey was conducted among the stakeholders engaged in constructed projects in various cities of South Africa to collect data. Liker scale was used to evaluate the relative importance of various factors influencing contractor commitments. System Dynamics (SD) modelling principle was used to develop the causal feedback relationships among the variables and evolve regenerative mechanisms that would assist to resolve the challenges. The evaluation suggests that lack of experience, skill, inadequate supervision, and lack of control over the subcontractors are the major parameters which lead to contractor's inefficiency. Poor quality of work and delay are caused by poor planning and scheduling, poor professional management, poor execution of projects, ineffective/outdated equipment, and inefficiency of labour force. Furthermore, design and documentation challenges disrupt the contractors' schedule. The inter-linkage among these factors adversely impact contractor commitment. It is also found that policy/strategic interventions based on the causal feedback relationships among contractor efficiency, and (1) capacity building; (2) professional management; (3) construction methods; and (4) involvement of the contractor and client in the design process would enable the contractors to overcome their challenges to meet their commitment and improve efficiency in project delivery.

2 LITERATURE REVIEW

Contractors are essentially responsible for the actual construction activities. Honouring of contractual agreements by contractors plays a major role in the successful

project delivery (Ndekugri, Braimah, and Gameson, 2008). However, according to Chan and Kumaraswamy (1997) and Satyanarayana and Iyer (1996) lack of contractor commitment may lead to project delays and other unwarranted consequences such as, cost escalation and poor quality of work.

Evidence from literature shows that a number of factors contribute to the lack of commitment of the contractors. For example, Alwi and Hampson (2003) and Sweis, Sweis, Hammad, Abu (2008) observed that contractor's inability and inefficiency cause delay and influence project delivery, which was corroborated by other scholars. According to Olawale and Sun (2010), non-performance of contractors/subcontractors within four key principles of construction management such as preventive, predictive, corrective and organizational support is one of the major impediments against successful project delivery. Besides, a common set of contractor ability criteria, which includes engineering/construction, procurement/contract, project management, human resources, quality management systems, health and safety, plant/equipment, financial strength, and public relations also influence project delivery (Pongpeng, and Liston, 2003). Inadequate experience of contractors, contractors' inability and inefficiency, poor labour productivity, lack of control over subcontractor and financial difficulties faced by the contractors, contribute to the commitment challenges faced by the contractors and adversely impact the project delivery (Sweis, Sweis, Hammad, Abu, 2008). Lack of trades' skill, poor distribution of labour, inadequate number of supervisors/foremen, inexperienced inspectors, late supervision, and shortage of manpower (skilled, semi-skilled, unskilled labour) are the factors that adversely influence delivery of projects on time (Satyanarayana and Iyer, 1996; Odeh and Battaineh, 2002; Alwi and Hampson, 2003; Sambasivan and Soon, 2007; Sweis et al., 2008). Furthermore, lack of skill and competency of human resource in their disposal, such as subcontractor or labourers are some of the major factors that adversely affect project delivery time (Satyanarayana and Iyer, 1996; Odeh and Battaineh, 2002; Alwi and Hampson, 2003;; Sambasivan and Soon, 2007; Sweis et al. 2008).

Satyanarayana and Iyer (1996), Odeh and Battaineh (2002), Sambasivan and Soon (2007), and Sweis, et al. (2008) observe that professional management challenges faced by contractors hamper their commitment, and consequently contribute to delay in the delivery of projects. The professional management factors, which contribute to delay in project delivery are poor site management and supervision, delay in material delivery by vendors, and site accidents due to lack of safety measures. Similarly, according to Alwi Hampson (2003), Odeh and Battaineh (2002) and Sweis et al. (2008) project execution could negatively impact the contractor commitment on project delivery. According to them, too much overtime for labour, inappropriate construction methods and mistake during construction, equipment shortage, poor equipment choice/ ineffective equipment, outdated equipment and poor site layout do not allow the contractors to honour their commitments for successful project delivery (Odeh and Battaineh, 2002; Alwi and Hampson, 2003; Sweis *et al.,* 2008).

Design and documentation is also a factor mentioned in the literature which significantly influences contractor commitment and in turn influence project delivery (Odeh and Battaineh, 2002; Alwi and Hampson, 2003; Sweis *et al.,* 2008). Poor quality

site documentation, unclear site drawings supplied, slow drawing revision and distribution, design changes, poor designs, and too many change orders from owners/clients are some of the design and documentation related factors, which impact on the contractor commitment and cause delay in project delivery (Odeh and Battaineh, 2002; Alwi and Hampson, 2003; Sweis et al., 2008).

Besides, improper and inadequate material supply impedes the speed of construction of a project relative to on time delivery. Poor quality of the material, poor material handling on site, poorly scheduled delivery of material to site, inappropriateness/misuse of material, poor storage, etc., do not allow the contractor to keep the project on schedule and thus fail in his commitment to deliver the project in time and within the estimated budget (Alwi and Hampson, 2003). Thus, it is seen that factors relating to contactors inability and inefficiency, professional management, project execution and design and documentation influence contactors commitment and consequent project delivery significantly.

However, it is also found that although many of these factors are interlinked and have cause and effect relationships (Assaf and Al-Hejji, 2006; Sambasivan and Soon, 2007), explicit studies relating to causal feedback relations and their influence on construction delay are found to be limited. So, the importance of early identification of contractor commitment challenges and establishing of inter-linkage among the factors and development of mechanism for resolving contractor commitment issues and major delay reducing remedies that have been stressed by a number of scholars are highly essential (Alaghbari, Razali, Kadir, Ernawat, 2007; Das, 2015; Sweis et al., 2008).

3 RESEARCH METHODS

The investigation follows a survey research method and qualitative System Dynamics (SD) modelling approach. A survey was conducted by using the perception of professionals in organisations, relative to construction projects in four major cities in South Africa namely, Bloemfontein, Cape Town, Durban, and Port Elizabeth. Initially a questionnaire was prepared and pre-tested through a pilot survey among 10 professionals and based on the responses and a feedback obtained through the pilot survey informed the final questionnaire preparation. The final questionnaire included factors which impact contactors commitment under various attributes such as contractors' ability and efficiency, professional management, execution, and design and documentation. The sampling frame consist architects 346 (SAIA); master builders 513 (MBA); clients 91 SAPOA); structural engineers 39 (CESA - East Cape), and *quantity surveyors 420 (ASAQS). From these* the sample sizes *were calculated and the questionnaire response rate according to professional is given as:* architects (9), master builders (18), quantity surveyors (23), and structural engineers (23), clients (12) and others (3), which equates a total of 88 (6.1%) responses were obtained.

Sample selection was done by using probability sampling technique. Random sampling was used for the group of respondents that include architects, master builders, and clients. For quantity surveyors, and structural engineers, systematic stratified random sampling technique was used and for project managers convenient sampling

technique was adopted. The survey was administered by asking the respondents to complete and return a questionnaire through post or e-mail.

Table 1 Profile of respondents

Respondents	Number	Share in %
Architect	9	10.23
Master Builder/ Contractors	18	20.45
Quantity surveyor	23	26.14
Structural Engineer	23	26.14
Clients	12	13.64
Project managers	3	3.40
Total	88	100.00

The sample size and response rate was considered fairly adequate for the statistical analysis because (1) the professionals concerned are from the middle and higher level in the hierarchy in the projects and they are limited in numbers and (2) the response rate is quite significant (more than 40%) which eliminated bias if any (Kothari, 2004). Further, as seen from Table 1 the respondents belong to a heterogeneous and diverse group. This implied that the information provided by the respondents can be relied upon for the purposes of the analyses.

The contractor commitment challenge variables were evaluated by using five point Likert scale in which 1 represents lowest influence and 5 represents maximum influence (Gravetter and Wallnau 2008). The evaluation was conducted by using the mean score from the responses obtained from the respondents. Cronbach's coefficient test and validity test were performed and were found satisfactory. Cronbach's alpha of $\geq .97$ and factor loading of $>.60$ for samples sizes 85-89 were obtained.

Followed by SD principle based on System thinking approach (Forrester, 1968; Stermann, 2000) was adopted to extract the causal feedback mechanisms that cause contractor commitment challenges, and to evolve plausible policy interventions to resolve the challenges. SD principle was adopted because its rigorous structural framework assists in eliciting and displaying information used to build a conceptual model (Forrester, 1994; Han, Love, Peña-Mora , 2013; Kim and Reinschmidt, 2006; Lane and Oliva, 1998; Lyneis, and Ford, 2007; Rahmandad, and Hu, 2010; Wolstenholme, 1992).

For developing causal feedback relationships, initially the variables were categorized into four variables such as information, decision and action and environment (system) variables (Olaya, 2012). Then variables are then connected with simple one way causality in terms of one way linkages of information – decisions – actions – impact on the environment. In other words the variable are linked in a manner that information assists in evolving decisions (policy interventions), decisions lead to appropriate actions, and actions influence the environment (system)) and (Veniix 1996

and El Halabi et al., 2012) with their influence on one another (Fig. 1). Once the one way causality is established, feedback relationships among the variables are checked and established (Aiyetan and Das 2015). However, the causal feedback relationships developed were with professionals and experts to check the validity of the causal diagrams. Appropriate modifications with regards to variable names, their polarity and causal relations are made as per the feedbacks from the expert discussion. Conceptual SD models and regenerative mechanisms were then developed from the valid causal feedback diagrams (causal loop diagrams).

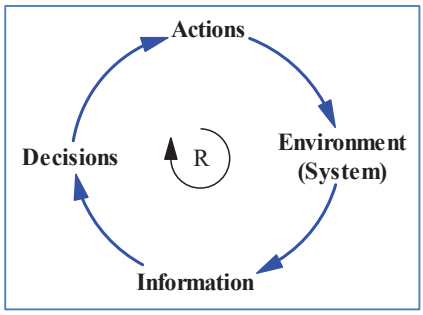

Fig. 1. Methods adopted for construction of causal feedback relations (Adopted from Olaya, 2012; Aiyetan and Das, 2015)

4 RESULTS, CONCEPTUAL MODELS AND DISCUSSIONS

4.1 Factors Influencing Contactor Commitment

Table 2 presents the mean score of the of the various factors under different attributes like contractor ability, professional management by the contactor, design documentation, and project execution that influence contractor commitment in a five point Likert scale (1 indicates least influential and 5 indicates most influential). It is noteworthy that all the factors have a mean score greater than 3, which indicates that all the parameters have positive influence on contractor's commitment in construction projects delivery. Among these, it is seen that under Contractor's inability and inefficiency attribute: lack of skill, late supervision, availability of too few supervisors, delay caused by subcontractors, lack of control over subcontractors, and poor labour productivity are the major factors which significantly hamper contractor commitment in the projects. Similarly under professional management attribute poor site management and supervision, delay in material delivery by vendors, poor planning and scheduling and Site accidents due to lack of safety measures are the major factors, which reduce contractor commitment. Besides, under project execution attribute: equipment shortage, outdate equipment and too much overtime for labour significantly prompt contractor

commitment challenges. Furthermore, it is also found that under design and documentation attribute the major factors which cause contractor commitment challenges include, poor design, poor quality site documentation, unclear site drawings and too many change orders from owner/client. However, since all the parameters contribute to contactors commitment challenges to certain extent and are vital in construction process they have been considered for developing the causal feedback relationships and examining their implication on the project delivery. The causal feedback relationships among the factors and development of mechanisms to resolve the challenges are considered separately under each attribute. The conceptual SD models and resolving mechanisms were developed by using SD modelling principles.

Table 2. Factors influencing Contractors lack of commitment

Factors influencing lack of contractor commitment	Index based on Likert scale mean value	Sources
Contractor's inability and inefficiency		
Lack of trades' skill	3.98	Alwi, and Hampson, (2003); Sweis et al., (2008)
Poor distribution of labour	3.62	
Supervision too late	4.01	
Too few supervisors/foremen	4.25	
Lack of subcontractor's skill	3.52	
Inexperienced inspectors	3.03	
Shortage of manpower (skilled, semi-skilled, unskilled labour)	3.45	
Ambiguity in estimations	3.76	Satyanarayana and Iyer (1996); Odeh and Battaineh (2002); Sambasivan and Soon (2007); Sweis et al., (2008)
Inadequate experience of contractor	3.15	
Poor labour productivity	3.76	
Lack of control over subcontractor	3.85	
Delay caused by subcontractors	3.91	
Financial difficulties faced by the contractor	3.18	
Professional Management		
Poor site management and supervision	3.92	Odeh, Battaine (2002);Alwi, and Hampson, (2003); Sweis et al., (2008); Satyanarayana and Iyer (1996);Chan and Kumaraswamy (1997); Odeh, Battaine (2002); Sweis et al., (2008)
Delay in material delivery by vendors	3.73	
Site accidents due to lack of safety measures	3.54	
Lack of motivation for contractor	3.40	
Poor planning and scheduling	3.73	
Poor provision of information to project participants	3.21	
Poor coordination among project participants	3.33	
Slow in making decisions	3.46	
Execution		
Too much overtime for labour	3.87	Odeh, Battaine (2002); Alwi, and Hampson, (2003); Sweis et al.,
Inappropriate construction methods and mistake during construction	3.05	
Equipment shortage	3.91	

Poor equipment choice/ineffective equipment	3.27	(2008)
Outdated equipment	3.74	
Poor site layout	3.28	
Design and Documentation		
Poor quality site documentation	3.37	Odeh, Battaine (2002);
Unclear specifications	3.12	Alwi, and Hampson,
Unclear site drawings supplied	3.37	(2003); Sweis et al.,
Slow drawing revision and distribution	3.37	(2008)
Design changes	3.12	
Poor Design	3.37	
Too many change orders from owner/clients	3.37	

4.2 Causal Feedback Relations Causing Contractor Commitment Challenges and Mechanisms to Resolve the Challenges

4.2.1 *Contractor ability and efficiency*

Contractor ability significantly influences contractor commitment. The survey findings suggest that with mean score higher than 3.5; various contractors ability related factors as shown in Table 1, significantly influence contractor commitment and cause the contactor to weaver from his commitments. Besides, the factors develop a chain of causality and feedback relationships among themselves. As seen in Figure 2 (a) and 2 (b) lack of experience leads to inadequate supervision and lack of control over the subcontractors. Delay is caused because of the lack of control of the contractor over the subcontractors and lack of skill availability with the subcontractor. Besides, lack of experience contributes to lack of availability of skill with the contractor through a disruptive causal feedback mechanism IB1. Poor skill and poor financial management in addition to inaccurate or ambiguous estimate make the contractor face financial difficulties (IB1A), which contributes to the inefficiency of the contractor. Similarly, shortage of skilled manpower is a key challenge faced by the contractor. Due to shortage of man power, the contractor fails to appropriately apportion labour in the project, which essentially leads to poor labour productivity as shown by causal feedback mechanism IB2.

However, as revealed from causal feedback diagram in Figure 1(a) and reinforcing mechanism in Figure 2 (c), skill and competency building can assist in reducing the inefficiency of the contractor. Skill training, financial management training will enhance the finance management capacity of the contractor, which may assist to find ways to reduce financial difficulties faced by the contractor (IR1A). Skill training and internship will make the contractor more competent to handle shortage of manpower by recruiting adequate manpower (IR1B). It will also assist in enhancing labour productivity. Besides, capacity building will also assist the contractor to gain from experience and use the experience gained effectively (Figure 2 (c)). Subcontracting experience before handling jobs as a contractor is expected to deal with the challenges related to subcontractors such as control, delay and lack of skill (IR1C). All the three aspects will enhance the capacity and competence of the contractor eventually leading to increase in efficiency of contractor.

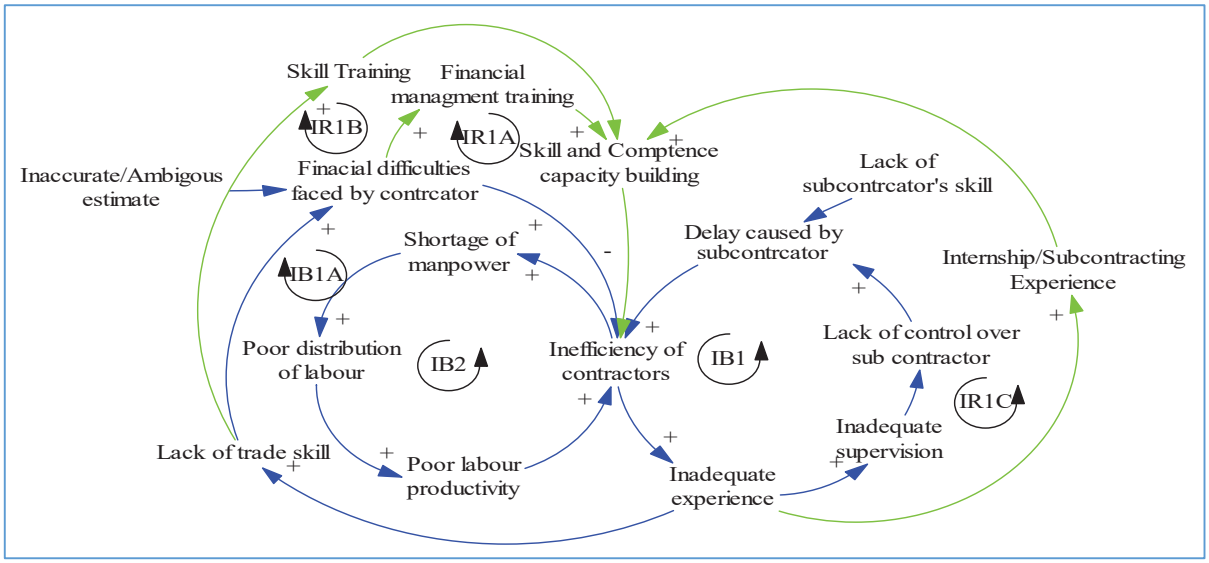

Figure 2 (a) . Causal feedback relationship for contractor efficiency in projects *(Blue lines show the challenges and green lines show the interventions)*

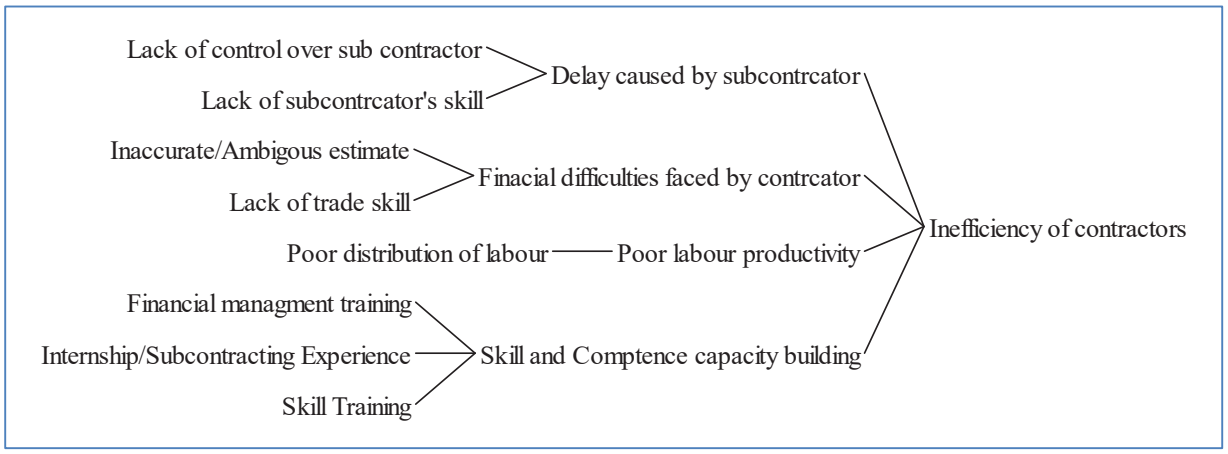

Figure 2 (b). Disrupting mechanism causing contractor efficiency in projects and poor contractor commitment

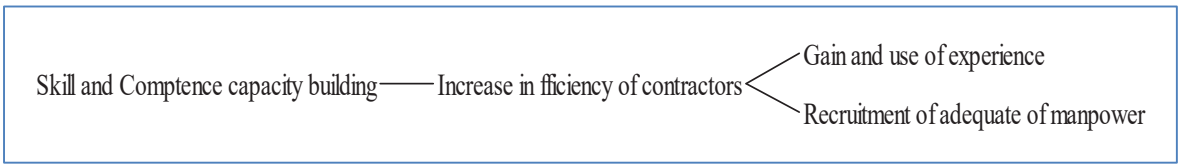

Figure 2 (c): Reinforcing mechanism increasing contractor efficiency in projects

4.2.2 *Professional management*

Professional management is one of major elements in the contractor commitment. Poor professional management is influenced by two important mechanisms. First, poor planning and scheduling in project in addition to lack of proper facilities for information transfer lead to poor communication and coordination, and essentially create delay in decision making. Consequently, the project is not managed as it is envisaged. This phenomenon is presented by a disruptive mechanism PB1 (Figures3 (a) and 3 (b)). Similarly, on the other hand lack of professionalism lead to lower morale and motivation of the contractor. The lack of motivation may lead to poor management of site (as shown by feedback mechanism PB2), which in fact can be exacerbated by the delay in material delivery due to poor planning and scheduling and consequent poor coordination and communication (feedback mechanism PB1A). Thus, these two major disruptive feedback mechanisms bolster poor professional management of the projects and force the contractors to fail to keep their commitments. However, if the capacity of the contractors is enhanced through capacity building as discussed in earlier sections (cf4.1.1), it will assist the contractors to adept in project management skill and techniques to prepare appropriate plans and schedules. Besides, available information communication transfer facilities in addition to capacity building will reduce poor coordination and communication and enhance decision making. The net result shall be enhancement in professional management of the projects (PR1). Again, appropriate coordination and communication facilities will enable reduction in delay in material delivery leading to better site management through reinforcing mechanism PR1A. Similarly, capacity building of contractors will act as incentives and rewards for the contractors that will boost the morale and motivate the contractors. The increase in motivation will cause better site management and consequently lead to professional management of the projects through feedback mechanism as shown by PR2, which will further bolster by the increase in the health and safety measures through feedback mechanism PR2A. Thus, the poor professional management of projects by contractors, which are essentially augmented by disruptive mechanisms PB1 and PB2 can be countered by feedback mechanisms PR1and PR2. Overall as shown in the reinforcing mechanism (Figure 3 (c)), capacity building will engender knowledge and skill in project management, assist in provision for incentives and awards to contractors and improve health and safety aspects in projects, which consequently will lead to proper planning and scheduling, improve motivation of contractors, and reduce accidents in

site respectively, thus reducing delay in projects. Therefore, if the capacity of the contractors is enhanced in addition to improvement in information and communication facilities, then the projects would be managed more professionally; that will enable the contractors to keep their commitments.

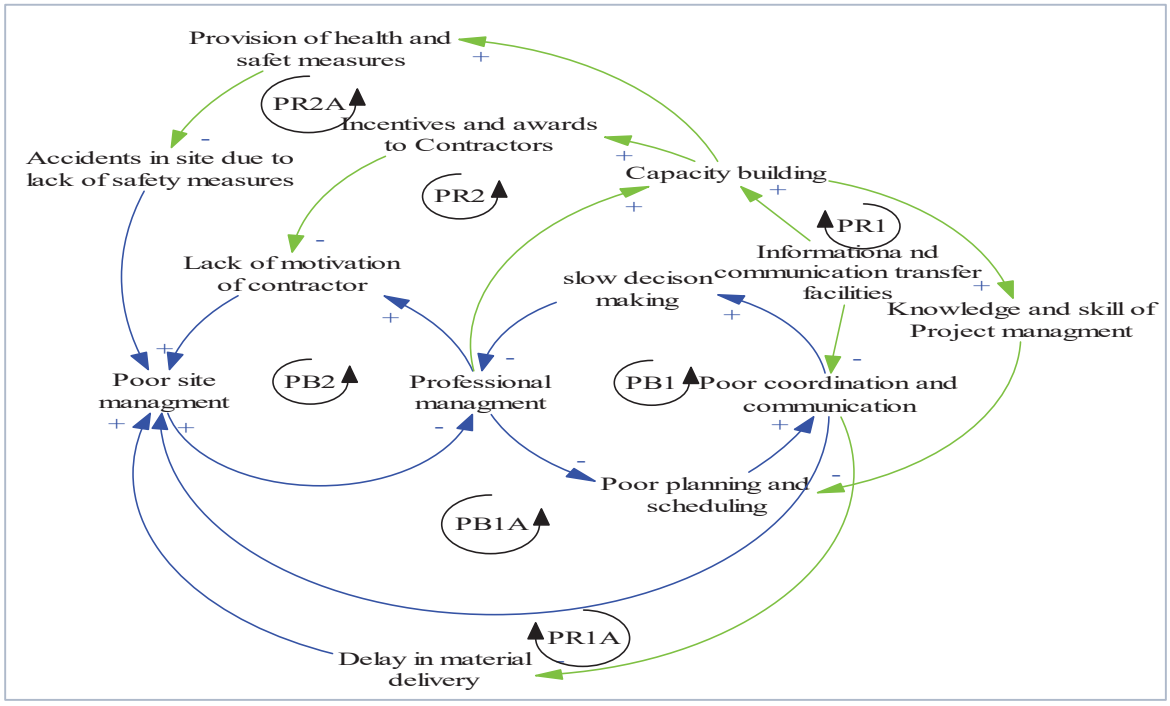

Figure 3 (a). Causal feedback relationship for professional management of projects by the contractors

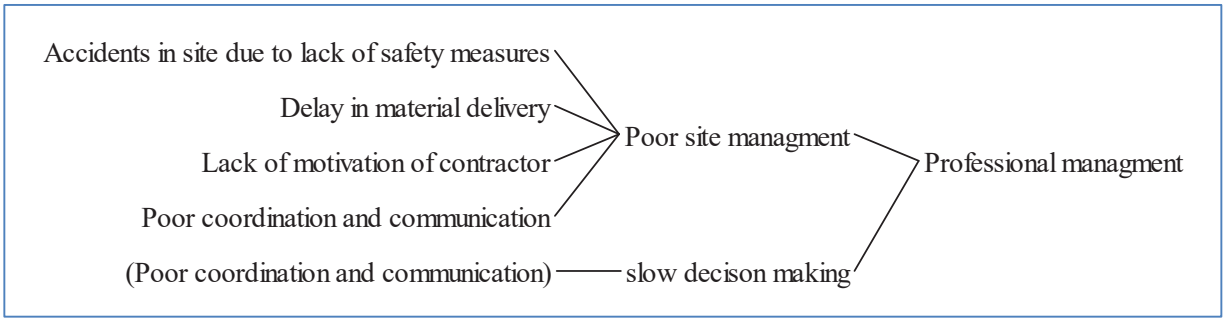

Figure 3 (b). Disrupting mechanism causing poor professional management in projects leading to poor contractor commitment

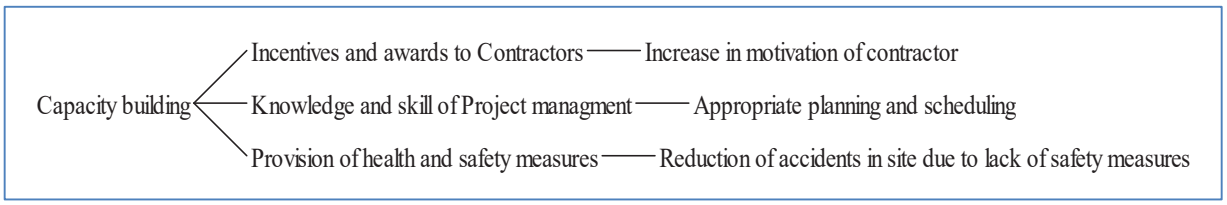

Figure 3 (c): Reinforcing mechanism increasing professional management by contractors in projects

4.2.3 *Project execution*

Challenges in execution of project significantly influence the contractor commitment in project. As indicated in Figure 4 (a and b), poor execution of projects is caused by ineffective/out-dated equipment's, inefficiency of labour force and poor planning and scheduling and site planning. Ineffective or outdate equipment if used along with the excessive overtime of labourers lead to efficiency of labourers resulting in poor execution of the project through a disruptive mechanism EB1. Similarly, poor planning cause shortage of equipment that hampers the smooth execution of the projects (feedback mechanism EB2). Poor planning also cause poor site layout, which reduces the outputs of labour force and aggravate the challenges of project execution through a feedback mechanism shown by EB3. The situation gets exacerbated further if appropriate construction methods are not used in construction, which essentially create errors and delay in the projects (EB4). Thus, as observed, because of the dominant disruptive mechanisms, (1) inappropriate construction methods leading to error and delay in construction, (2) ineffective and out-dated equipment, excessive overtime of labourers and poor site layout leading to inefficiency of labour force, (3) and unavailability of proper equipment and poor planning leading to shortage of equipment make the project execution to suffer forcing the contractors to waver away from their commitments (Figure 4 (b)).

However, strong professional management of the projects and knowledge about the appropriate construction methods, appropriate technology and equipment could assist in resolving the challenge. Professional management generally assists in proper planning and scheduling. Proper planning and scheduling alleviates the challenges of project execution in three ways. First, it makes provision for availability of adequate and appropriate equipment's via availability of finance, which neutralizes the negative effect of the ineffective and out-dated of equipment and improves the execution process (Feedback mechanism ER1A). Second, the availability of equipment also reduces the effects of shortage of equipment (ER1B). Third, proper planning improves the site planning scenario, which essentially enhances the efficiencies of the labour force (feedback mechanism ER1C) and also saves the additional expenditure because of the excessive overtime by labourers'. Besides, if the capacity of the contractors is build,

which essentially enhances the knowledge and competency of the contractors about the equipment, technology and construction methods, then contractor will be able to reduce the errors and delay caused by the challenges of use of improper construction methods. Essentially, this mechanism neutralizes the negative effects of the disruptive mechanism EB4. Also, such a mechanism reinforces the mechanism ER1B and counteracts the challenges of poor execution of projects. Therefore, as presented in Figure 4 (c), professional management, appropriate planning and scheduling in addition to knowledge and competency of the contractor remain at the core to improve project execution, which consequently will ease the challenges of contractor commitment in the projects.

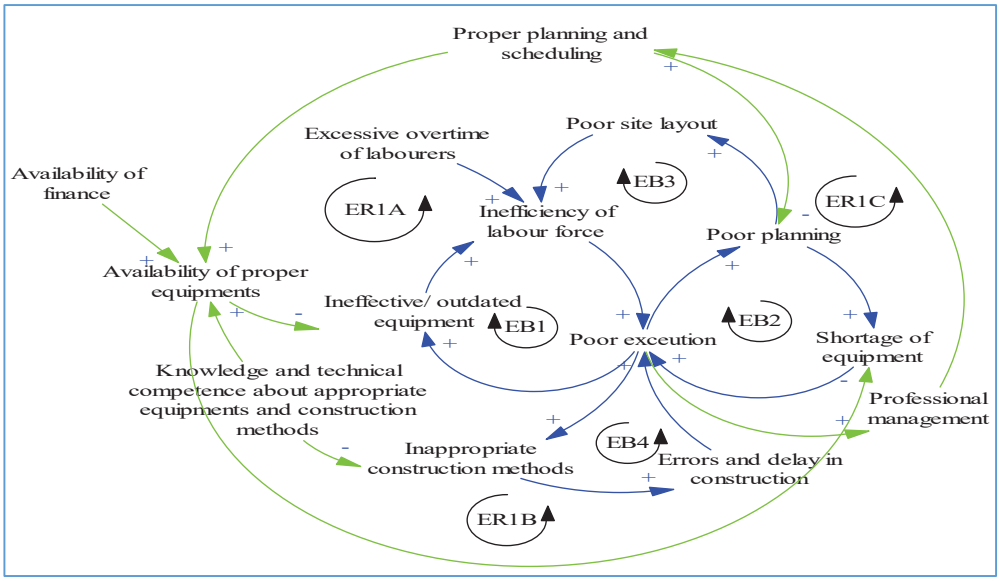

Figure 4 (a). Causal feedback relationship for Execution of projects by the contractors

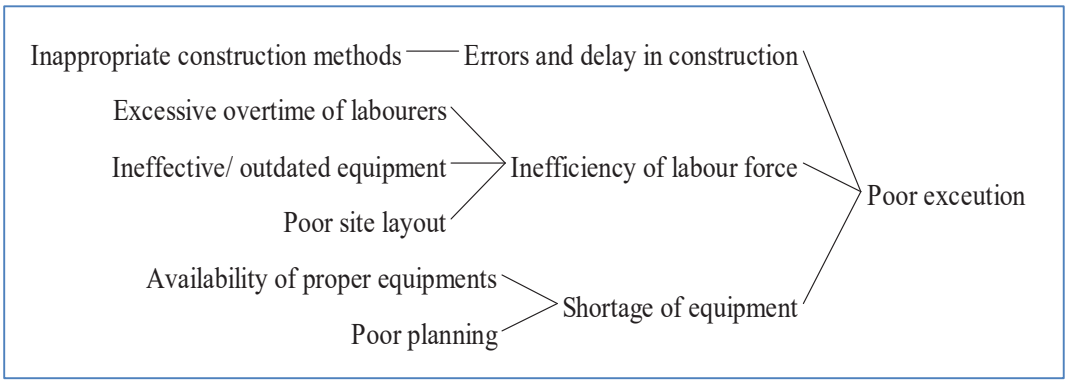

Figure 4 (b). Disrupting mechanism causing poor execution in projects leading to poor contractor commitment

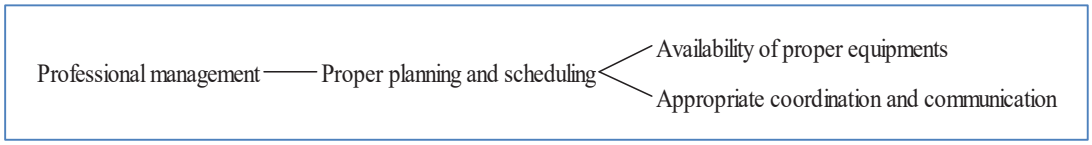

Figure 4 (c). Reinforcing mechanism to improve project execution by contractors in projects

4.2.4 *Design and documentation*

Design and documentation are essentially the responsibilities of the consultants and designers. However, client has significant influence on them. Poor design can create all sorts of challenges in the construction including influencing contractor commitment as reflected in different mechanisms in Figure (5 a and b). Poor design can result, because of the in-competency of the consultants. However, more often design changes at the client's behest are the major causes of poor design. The reason being, the client's uncertainty or lack of clarity on the final outcome may make the consultant unsure about the design. So, design changes lead to poor design and consequently there will be lack of appropriate details in design, drawings and material specification, which essentially disrupts the contactor's work schedule and commitment through a feedback mechanism DB1. Simultaneously, lack of details in design, drawing and material specification on account of poor design leads to unclear site drawing and poor documentation. The slow revision of design and drawing and their slow distribution also aggravates the poor documentation scenario. Poor quality design, drawing and specification documents generally make the contractor lose clarity in construction and consequently the construction work gets interrupted through a feedback mechanism DB2. In summary, as shown in the disruptive mechanism in Figure 5 (b) lack of contractor's involvement in design and documentation process causes lack of clarity in the design changes, site drawings and specifications. In addition to the factors such as slow in revision and distribution of design and drawings, which may lead to poor quality documentation and poor design engendered from design changes prompt for inadequacy in detailed design, drawings and materials specification to be provided to contractors through proper documentation process. In the absence of such detailed documents, the contractor may not be able to handle the project effectively and weaver from the commitments made for the project.

However, conversely involvement of the contractor and client in the design process, and coordination and communication among the client, consultant and contractor could ease the challenge. The clients' involvement in the design process shall lead to the consultant(s) to understand the clients demands and consequently the number of changes that can occur from clients side will be minimized and thus resulting in improvement on the design through feedback mechanism DR1. Similarly the

contractors, involvement in the design process particularly with regards to detailing in design, drawings and specifications will enhance the clarity in the specifications in the site drawings and materials use (DR2). Clarity in the drawings and specification in other words good quality documentation enable the contractors to work without much interruption. Besides, coordination and communication among the clients, consultants and contactors assists in minimizing the design changes as well as enhances the progress in revision and distributions of designs, drawings and other changes that may occur. In other words coordination and communication among the three stakeholders also strengthens the feedback mechanisms DR1 and DR2. Thus, it is seen that disruptive feedback mechanisms DB1 and DB2, which make the contactors to fail to keep their commitments are balanced by reinforcing mechanisms DR1 and DR2, which enable them to honour their commitments because of design related challenges. In other words as envisaged from the reinforcing mechanism as presented in Figure 5 (c), contractor's involvement in design and documentation remain pivotal to improve contractor commitment as the contractor would be aware of the details of the design, drawings, specifications and the changes if any in any of these aspects. Furthermore, because of his engagement in the process and awareness of the various aspects, there would be reduction in design changes (from contactors point of view) and lesser confusion on the drawings and material specification. As a result the contractor could able to execute the projects more efficiently contributing significant improvement in contractor commitments.

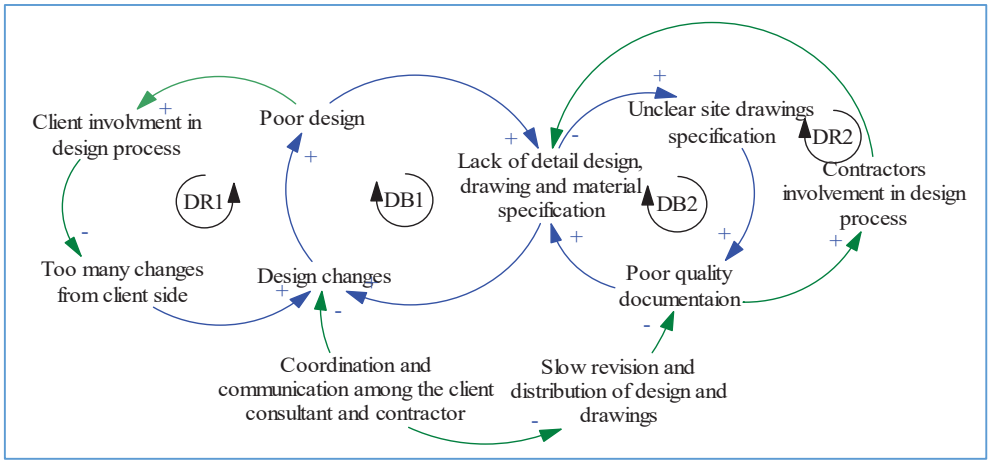

Figure 5 (a) . Causal feedback relationship for contractor commitments because of design and documentation challenges

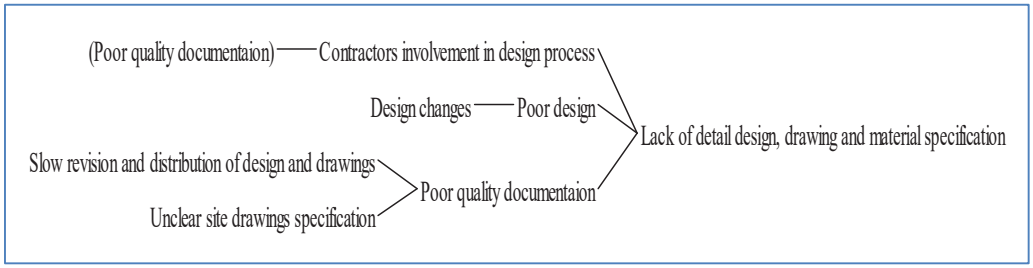

Figure 5 (b). Disrupting mechanism leading to lack of detail design, drawings and material specification contributing to poor contractor commitment

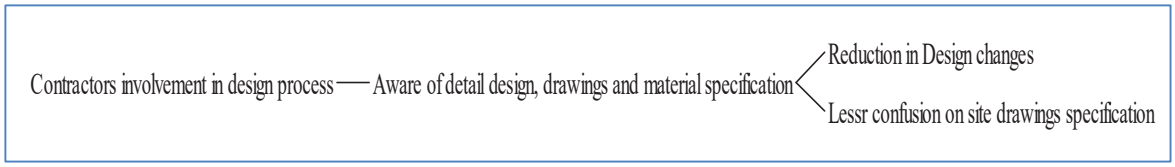

Figure 5 (c). Reinforcing mechanism to improve design and documentation by contractor's involvement in design and documentation process leading to enhanced contractor commitment

4.3 Discussions

Contractor commitment is at risk because of various contractor ability and efficiency, professional management, project execution and design and cementation related factors. It is found that almost all the factors under these attributes as mentioned in Table 2, essentially influence contractor commitment. However, identification of factors does not suffice to how these factors influence contractor commitment, what kind of causal feedback mechanisms do they develop to create contractor commitment challenges and how the challenges can be resolved. As suggested by Assaf and Al-Hejji (2006) and Sambasivan and Soon (2007), there is a necessity to establish the inter-linkage among these factors. In this regard, development of conceptual models and consequent mechanisms by using SD modelling principles (Stermann, 2000) is found to be useful and relevant. As suggested by Montibeller and Belton (2006), Robinson (2008), Das (2015) and Aiyetan and Das (2015), use of conceptual models to understand the inter-linkage among the factors influencing contactor commitment and development of the contractor commitment disrupting and reinforcing mechanisms will assist in development of policy interventions to alleviate contractor commitment challenges in construction. Such mechanisms would enable the contractors and other related stakeholders to take steps to resolve contractor commitment challenges through qualitative understanding in a cost effective way and without making elaborate quantitative investigation that could be time consuming and expensive. Consequently, it is found that conceptual SD models engender a set of disruptive mechanisms, which reduce contractor commitments, and reinforcing mechanisms that would resolve the

challenges. The mechanisms are established based on the inter-linkage among various contractor commitment related factors and their cause and effect as well as feedback relationships. The findings of the conceptual SD models reveals that the influence of various disruptive mechanisms caused because of different contractor linked factors suggested by various investigators (Odeh and Battaineh, 2002; Alwi and Hampson, 2003; Sweis *et al.,* 2008) can be negated by the policy interventions that can be developed based on the reinforcing mechanisms extracted through the SD Conceptual models. In this regard, attributes such as contractors' ability and efficiency, professional management, project execution and design documentation are found to be pivotal for the contractor to adhere to commitments. For example, skill and competency building, which can be attained through skill training, project management training, financial management training, etc., would engender knowledge and skill in construction, finance management, labour management, project management, etc., consequently enable the contractors to reduce inefficiency. Similarly, capacity building will motivate for higher incentives and awards to contractors. Furthermore, professional management skill will allow the contractors to the plans and schedules of the projects, enable proper project execution and improve health and safety aspects in projects, and reduce accidents in site, thus reducing delay in projects. Moreover, contractor's involvement in design and documentation will make them aware of the details of the design, drawings, specifications and the changes if any in any of these aspects, which would lead to reduction in design changes and lesser confusion on the drawings and material specification. Consequently the cumulative effect would result in higher efficiency, execution as per contract and schedule and reduction in delay, thus contributing significantly to improve contractor commitments.

5 CONCLUSIONS

Contractor commitment in construction projects is a major issue faced in the construction industry. A number of attributes and factors are responsible for reduced contractor commitments, which adversely influence successful project delivery within the stipulated time and budget. Several studies have been conducted to understand the causes of lack of contractor commitments; however the studies related to the inter-linkage and causal relationship among the factors influencing contractors' commitment are limited. Therefore the , objectives of the investigation were to identify the relative influence of the various factors that adversely impact contactor commitments in a project; to explore causal feedback relationships among the major influential factors hampering contractor commitment; and to develop regenerative mechanisms to resolve the contractor commitment challenges. To realise the aims a survey research method and application of conceptual SD modelling principles were adopted by considering construction projects in important cities of South Africa. The findings suggest that a number of factors (Table 2) under different attributes such as ability and efficiency of the contractors, professional management, project execution and design and documentation of projects influence contractor commitment significantly. The inter-linkage among the factors under each attribute and their feedback relationships cause

disruptive mechanisms which essentially cause contractor commitment challenges in the projects, which warrants policy interventions. The conceptual SD models also indicates that reinforcing mechanisms can be engendered based on the factors, which can act as antidotes to the disruptive mechanism and improve contractor commitment. Furthermore, this investigation reveals that the causal feedback mechanisms among the factors can make the contractors and other stakeholders understand the contractor commitment challenges and engender strategic interventions to resolve these challenges qualitatively. As found from this investigation, the challenges and resolution mechanisms seem to work in a chain of causality and isolated policy interventions may not achieve the desired results, i.e., improve contractors' commitment and successful project delivery. The study has some limitations such as it is carried with limited data acquired from survey and only conceptual modelling was done. Availability of statistical data as well as a comprehensive computational model could have provided more insights to the problem, which is the further scope of the research. However, in the current state, the findings of the evaluations regarding the factors causing contractor commitment challenges and conceptual models based on inter-linkage of the factors can allow the stakeholders in a project to foresee the causal effects, understand the mechanisms that cause contractor commitment challenges and develop appropriate strategy interventions to make the contractors to adhere to commitments and execute the projects within schedules and resources.

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