4 A Systematic Approach to Modelling Change Processes in Construction Projects

Ibrahim A. Motawa (Department of Structural Engineering, Faculty of Engineering, Mansoura University, Egypt)

ABSTRACT

Modelling change processes within construction projects is essential to implement changes efficiently. Incomplete information on the project variables at the early stages of projects leads to inadequate knowledge of future states and imprecision arising from ambiguity in project parameters. This lack of knowledge is considered among the main source of changes in construction. Change identification and evaluation, in addition to predicting its impacts on project parameters, can help in minimising the disruptive effects of changes. This paper presents a systematic approach to modelling change process within construction projects that helps improve change identification and evaluation. The approach represents the key decisions required to implement changes. The requirements of an effective change process are presented first. The variables defined for efficient change assessment and diagnosis are then presented. Assessment of construction changes requires an analysis for the project characteristics that lead to change and also analysis of the relationship between the change causes and effects. The paper concludes that, at the early stages of a project, projects with a high likelihood of change occurrence should have a control mechanism over the project characteristics that have high influence on the project. It also concludes, for the relationship between change causes and effects, the multiple causes of change should be modelled in a way to enable evaluating the change effects more accurately. The proposed approach is the framework for tackling such conclusions and can be used for evaluating change cases depending on the available information at the early stages of construction projects.

Keywords: project change management, modelling processes, evaluation.

INTRODUCTION

Project changes, after a construction bid has been accepted, are common and likely. Inconsistent management of the change implementation can result in long delays and overestimated costs. Changes can be caused by design errors, a change in the functional requirement of the project, and unforeseen conditions. They always result in several consequences such as breaking of project momentum, increased overhead and equipment costs, scheduling conflicts, rework, and decreased labour efficiency. Some of these consequences can be relatively easy to measure, while others are more difficult to quantify. Changes are not often immediately well defined, but time has to be taken by the project team to consider the full definition of the changes. This is a significant part of managing the change process itself; furthermore, this may cause delays to the project as a consequence of change. Managing change is considered an integral part of project management (Hester et al., 1991; Voropajev,1998; and Williams, 2000). Therefore, a change process model is required to improve the management of projects.

Managing change at the project level relates all project internal and external factors that influence project changes. Several generic models for change process have been developed. The Construction Industry Institute (CII, 1994) established a concept for project change management where change is considered as a modification to an agreement between project participants. The CII report defined the project elements that are subject to change and that will affect the change process as project scope, project organisation, work execution methods, control methods, contracts and risk allocation. The interaction of these elements becomes significantly more complex as the project proceeds. Recommended practices for managing change efficiently were organised for each project phase of the project life cycle (CII Conference, 1996). A prototype change process system was proposed and included a set of 27 best practices for project changes. Cox et al. (1999) specified a generic procedure for issuing a change order request after contract award. Stocks and Singh (1999) developed a method called functional analysis concept design (FACD) by which owners and designers can partner during the design phase of projects to reduce the overall rate of construction change orders. A best practice guide has been published by CIRIA (2001) to present best practice recommendations for the effective management of change on projects. The guide proposed three change processes for changes during design development, post-fixity changes that are urgent, and post-fixity changes that will be implemented during the remainder of the project process. A toolkit was developed that contains pro-forms, flowcharts and schedules for use in the implementation of an effective change process system. Ibbs et al. (2001) introduced a change management system that is founded on five principles: 1) promote a balanced change culture; 2) recognise change; 3) evaluate change; 4) implement change; and 5) continuously improve from lessons learned. Each of these principles works hand-in-hand with the other to minimise deleterious change and promote beneficial change. The system composed of a level-one flow chart showing the five change management principles necessary to manage change and a series of level-two flow charts that show the specific activities involved with each of the level-one functional activities.

From the forgoing discussion of the literature, it can be seen that researchers have mainly focused on the identification of the change process and factors affecting the success of a change process and best practice recommendations for managing change during the project life cycle. While these recommendations are beneficial, they are not sufficient to manage the complex process of change, particularly when there are different change causes and consequences. Appropriate strategies for managing change can be improved when the cause-and-effect relationships of change are modelled and evaluated even before the change actually occurs. The evaluation of construction change should strive to establish these main elements: 1) project characteristics that lead to change; 2) causes of change; 3) the likelihood of change occurrence; and 4) the change consequences should it eventuate. It should also define the relationships between these elements. Cause-and-

effect relationships within the change process are important for understanding how changes occur and how the change causes influence the effects. Although the causes of change are factual, they may not be readily identifiable due to lack of information and they may also be interdependent. This paper presents a model developed to represent the key stages of change implementation. The model aims to analyse and build on the outcome of an extensive research done by the author in collaboration with several industrial partners in the UK. Details on the research methodology and data collection can be found elsewhere: Motawa et al. (2003a; 2003b; 2003c; 2004). Two approaches are proposed for managing change - reactive and proactive. In the reactive approach, the objective is to improve efficiency in handling changes after they have already occurred whereas in the proactive approach, the aim is to identify and forecast potential changes and develop solutions before the change occurs.

CHANGE PROCESS MODEL FOR CONSTRUCTION

The developed model is based on the process models adopted on a number of case studies undertaken during the research project. Many change events were monitored during live projects. The change process models, already adopted by the involved project teams (if any), were observed by attending several key meetings of the teams. The model developed from this, which is shown in Figure 1, is a generic change process model that can be applied to different change categories, such as pre- or post-fixity changes. The process model has four main parts, which are presented in the following sections. Appendix I demonstrates a hierarchy structure that includes details on each section.

1. *Pre Change:* At the "pre change" stage, the generic process defines a set of proactive requirements that are essential for effective change management. These requirements enable the project team to respond readily to change, to manage change effectively, and to facilitate contingency plans for any unanticipated changes. The main proactive requirements, shown on the upper level of the hierarchy, are:

1.1 Allocate resources for change management function
1.2 Initiate and select change management process for project
1.3 Approaches towards change management
1.4 Align project elements to change management process

The main functions that these requirements should provide, are:

- Project baseline and detailed cost and time plan. The project programme should be developed to manipulate change. A programme that satisfies this requirement should allow a late start for tasks subjected to change, identify the latest time for decisions to be taken and identify the time when the project information provided is complete.
- Knowledge base that includes criteria for deciding on change and evaluation in terms of the key project objectives (cost, time, quality and value issues).
- Integrated system for design management where management of the interfaces between designers and work packages are essential. It is also required for design rationale records for any change occurrence.
- 3-D modelling that assists fast and more detailed assessment of the impact of proposed construction changes.
- Procurement routes should consider change. The likelihood of changes becomes a criterion for selecting the procurement route.
- Value management and VE systems.
- IT communication facilities.
- Dispute resolution mechanism for any change that occurs.
- Risk analysis/management system that indicates:
    - Various risks that may occur at different times within the project life cycle.
    - The possibility of change occurrence that can be reasonably foreseen should be estimated (including its timing).
    - Risk analysis at an early stage will enable appropriate procedures to be established and appropriate contingencies to be prepared.
    - Scenario planning will help represent these changes.

2. *Identify and Evaluate Change:* Full change identification will help in evaluating the change and also during implementation. The approach adopted in this research classifies change identification into these main categories:

2.1 Monitor deviations from project programme
2.2 Analyse and consider implications of identified deviations
2.3 Develop mitigation strategy for change event
2.4 Update change management repository

The details of these categories, which are shown at the lower levels of the hierarchy in Appendix I, include: change types, causes and effects, and change initiator. The sub-categories of change causes and effects will be covered in more details later in this paper. The change types will affect the degree of change effects and the evaluation criteria of change. Types of change may be minor/major, required/elective, or pre-/post-fixity. Various criteria can be used to identify the change type such as:

- The need to rework;
- The volume of rework due to change in terms of costing and duration with respect to the project cost and duration;
- Size of disruption to the workflow.

Evaluation and analysis of change options are required for decision-making, whether to go ahead with any of the change options or to undertake further investigations. The criteria required to carry out this analysis should cover the tangible and intangible aspects of the project performance. The time-cost and cost-benefit analyses should also be considered. The evaluation stage needs experts' opinions. Therefore, the evaluation steps include options evaluation, implications assessment and optimum selection of change options. Different models and decision support systems can be used to help decision-makers select an optimum solution. For example:

- Financial models that incorporate financial parameters to control the operation at any one time;
- Linear models where decision criteria are subjectively weighted and rated by a decision-maker and combined into a single measure;
- Linear models incorporating multiple ratings that add the corresponding probabilities for the multiple ratings of a given criterion and measures the imprecision and uncertainty associated with the process;
- Multi-attribute utility models that develop a method to combine qualitative and quantitative decision criteria that are aggregated to arrive at an expected utility.

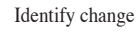

Figure 1: Generic change process model

- where risk, uncertainty, and the decision-maker's preferences are modelled and considered.
- Statistical models to evaluate quantitatively criteria relevant in decision-making techniques such as least squares regression of logistic regression where a dependent variable and an independent variable exist.
- Artificial intelligent (AI) systems, which combine qualitative and quantitative criteria in the form of heuristic rules. These models enable learning mechanisms for future projects. AI systems show valuable benefits in modelling qualitative criteria.
- Hybrid models, which integrate different systems to gain the advantages of all.

For this stage of the change process, the relevant project processes and departments affected by the change or involved in the change decision should also be defined. The model requires the project teams to keep records of all relevant information on change cases to build up a case base for future use. It was concluded from the case studies undertaken that the role of a 'change manager' is important to ensure effective change process management. The change management role can be executed by certain individuals that take the risks necessary to implement changes or can be executed by a member of the project team (e.g. project manager, architect). With advanced IT technologies, some roles of this manager can be carried out electronically such as information recording and propagating to the relevant project team (e.g. design team, construction team, cost team, programme input).

3. *Approval and Propagation:* Client approval is an important step in the process while different outputs are expected, as shown in Figure 1. The client needs to review potential changes against the project baseline using tangible and intangible criteria. In many cases, clients need to use decision-making techniques for evaluation and comparison in order to decide on a change option. Four possible approval status are defined:

- 'Yes', where the client approves the change proposal
- 'No', where the client rejects the change proposal
- 'Yes but not sure', where the client approves the proposal of change but the estimate for the time/cost is not acceptable so negotiations are needed to reach a compromise.
- 'Not sure', where the client agrees with a need for change but the change proposal is unacceptable so the case is returned to the project team for further investigation.

Implementing this stage of the process, which involves proposing change options and fixing the client's responses, establishes the case for change and the reference for solving any potential disputes if applicable. Therefore, the role of change manager is vital in this stage that also involves recording all proposal details. The rest of this stage, in Figure 1, involves integration between documentation and communication facilities.

4. *Post Change:* After the physical implementation of change, the case should be archived and analysed for future experience. Knowledge learnt should be kept for all project parties. The disruptive effects of change can be minimised when the project team can experience their knowledge about previous cases. The model defines the following categories for this stage:

4.1 Measure change effectiveness
- 4.1.1 Modification in physical properties
- 4.1.2 Changes in control systems
- 4.1.3 Changes in processes
- 4.1.4 Project and organisational performance criteria

4.2 Analyse work inactivity and ineffective work.

When dispute resolution is applicable, it requires the investigation of direct and indirect causes of change. In this situation, the diagnosis of the effect of multiple change causes should be considered. A methodology for such diagnosis is proposed in this paper and is presented in the following sections.

CHANGE DIAGNOSIS AND PREDICTION

The model described above recognises relationships between project characteristics inherent in the 'pre change' stage and change causes/effects inherent in the 'identify and evaluate change' stage as well as in the 'approval and propagation' stage. Analysis of such relationships is required to diagnose change cases that have already occurred, which is the approach towards reactive changes. Change diagnosis helps in investigating the change events for the purpose of analysis, learning and solving disputes.

However, studying these relationships at the early stages of projects can also help predicting potential changes in case they have not occurred yet for the purpose of minimising their disruptive effects. This is for the approach of proactive changes where the project team can take appropriate actions.

To reduce the disruptive effects of change, it is important to identify what project characteristics lead to change causes and what these causes are, and then to understand how these causes are related to effects. What are the internal mechanisms by which a particular factor causes a change in another factor? For example, how can poor communications lead to higher chance of change? How does an affected factor cause change in such a way that the former input factor ultimately gets affected? For example, poor communications leads to higher chance of change, but higher chance of change may eventually force improvements in communications.

Project characteristics, which represent the amount of information available at the early stages of a project, are often the original source of change cases as concluded from the case studies undertaken for this research - see Motawa et al. (2003b). Therefore, these characteristics are considered when simulating the cause and effect relationships of change cases. Figure 2 shows the typical relationship between project characteristics (F_i), causes of change (C_j), and change effects (E_k). Project characteristics are factors or aspects that have an influence on the project and may lead to change. Change causes are the direct causes of a specific change event when it occurs; these are likely to be because of the existence of the project characteristics. Change effects are the change consequences on the project parameters (eg. time, cost, etc). $\mathbf{R_{ij}}$ and $\mathbf{R_{jk}}$ are two measures that represent the degree of dependency between F_i's and C_j's and between C_j's and E_k's. They actually represent the sensitivity of the impact of one set of elements to variations in another set of elements.

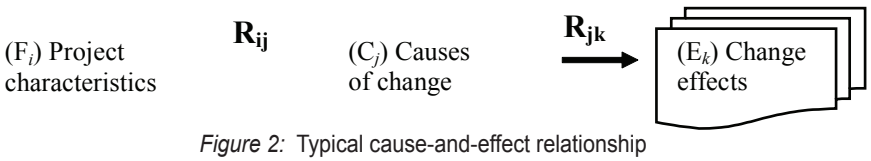

Figure 2: Typical cause-and-effect relationship

Lists of F_i, C_j, and E_k were identified through the case studies (Motawa et al., 2003b), which are categorised and re-examined in Appendix II. The main categories of the project characteristics, at the highest level of the hierarchy, are:

1.1 *Economic Issues.* The construction industry is significantly affected by macro economic conditions. Therefore, the global climate of the client and construction economy should be monitored to allow action to be taken when economic change is suffered.

1.2 *Demographic issues.* International, national and regional demographic shifts can impact on construction works. The volume/ the type of construction and the uses of the final facilities can all be impacted.

1.3 *Technological issues.* New technologies, taken up by the construction industry, arise due to a push and pull and are being developed continuously. Similarly the construction industry will drive technological development. Sometimes alternative inappropriate and immature technologies may prove to be a disruptive technology. Therefore careful evaluation of adoptive technologies must occur to ensure they will enhance the lifecycle and add value to the facility over its lifespan.

1.4 *Customer / stakeholder issues.* Identifying potential stakeholders to the project reduces risk and cost. Stakeholders may be internal or external. Internal stakeholders are those directly involved in the project, e.g. the client and the end-users. External stakeholders are those who are impacted by the project but do not have a direct stake on the project. The stakeholders' requirements should be appropriately considered.

1.5 *Legislative issues.* The governing power in a State will exercise an authoritative direction or regulation, which may cause change to occur.

1.6 *Competitor issues.* The construction client, in response to the needs of the market, should ascertain whether his services or the end user will change in such a way that will affect the construction project. This task ensures that the client has an appropriate level of market intelligence with which the business strategy may be affected. This can be especially helpful when exploring new geographical markets or business sectors.

1.7 *Environmental issues.* Many organisations lobby government to amend and create new policies and legislation associated with construction project regarding the environment. These should be monitored and evaluated. An impact assessment should be performed to indicate to what degree the change will affect the project and the stakeholders.

The "project characteristics" mentioned above have dealt with the information related to change at the early stages of projects. However, the direct causes of change can only be recognised when the actual implementation of the project shows the need for change. The main categories of the change causes, as shown in Appendix II, include:

2.1 *Process related issues.* A construction project is often comprised of a number of organisations temporarily working together and has to work as a team. It is important to consider how they interface with each other. First determine what processes are being used to aid the design and construction of the facility. Where a process is being used ensure that all organisations are working to the process. Where there is no process being used consider adopting an industry standard. A process should enhance the inter-organisational aspects of the project.

2.2 *People related issues.* The people involved in the construction process are a key component in the production of the facility, therefore, their needs and requirements should be considered. The team should have the correct skills and knowledge to undertake the project. Poor workmanship or individuals can cause errors that may lead to changes. The organisations participating in the project need an approach to the cultural issues. For example: How are they co-ordinated and managed? How are they encouraged to work together? How are their skills and knowledge nurtured and improved? What do they perceive as value? What do they consider their role to be? How are the different professional cultures integrated? Are there communication policies or procedures to adhere to? Are these effective?

2.3 *Resources related issues.* The project's technical issues for resources include innovations, complexity, user feedback and the incorporation of new products into the project. The financial and communications aspects for resources need to be considered.

2.4 *Design process change issues.* Design change is a natural result of the design process. When construction commences, it is advisable to have the design fixed. A correct design will almost certainly reduce the amount of disruption caused by change during construction. Post-fixity changes and errors in the design can have accumulated consequences over the construction lifecycle. On the other hand, current frameworks for design and construction promote concurrent working. As projects increase in complexity and many tasks are performed concurrently, an effective management system needs to be employed to ensure that tasks are synchronised.

2.5 *Construction process change issues.* This refers to alterations to the construction process as a result of adopting new construction techniques/methods. Changes could be minor field changes caused by site management. Problems can occur due to site conditions, workmanship, damage and accidents. Difficulties in work execution and control methods involved in the execution of projects can also cause changes.

Change effects may be constructive or disruptive. These are mainly categorised as direct and indirect effects. However, the change ripple effects should also be considered. These are the cumulative effects of change on tasks located on successive orders and also on supply chain members. The project processes and programme should be carefully studied and all stages and tasks with many logical links should receive special consideration.

Direct consequences of change are directly attributable to a change and have identifiable and clearly defined effects on the project. The consequences have quantifiable metrics, which include:

- Determination of whether the original tender sum has been or will be exceeded/reduced,
- Determining the deviation of the project duration from that stated in the contract documentation.
- Identification of the parties who are affected by the cost overrun/under run,
- Determination of the penalties or consequences to the affected parties,
- Consideration of the interrupted cash flow, financing costs and loss/growth of earnings.

The direct consequences of change also include rework and non productive time or non contributory work which refers to the loss

of time due to waiting or being idle, redoing work, stopping and restarting current tasks in order to make the variation. The areas, where the project has not delivered the required standard of quality and where a reduction or increase in the quality of the product or project is sought, should also be considered.

Indirect consequences of change would always be harder to identify and define than a directly attributable consequence. In terms of measurement, the metrics for these items will be qualitative. Examples of such indirect consequences include:

- Change may interrupt the schedule and thus cause delays and bottlenecks on the workflow.
- Change may promote uncertainty amongst the project team.
- There is often difficulty in determining equitable adjustment compensation for the parties involved.
- It may also impact on the amount of labour that is not being effectively deployed, or result in loss of learning curve.
- The team's momentum and equilibrium may be disrupted by a change event, therefore causing a normally effective team to become inefficient and ineffective for a period of time, which may increase co-ordination failures and errors.
- Change may alter the morale amongst the project team. Morale is a complex issue that could severely affect the project's performance.

The elements studied above, which are detailed in Appendix II, are used in the proposed approach to define the multiple relationships between causes and effects of change cases, as shown by the example in Figure 3. The studied cases of change, undertaken for this research, concluded that a change case may occur due to multiple causes, and the effects of this change may not be added linearly. Different causes of change may be responsible for a certain effect or a set of effects, as shown in Figure 3. The effect of a change cause C1 and C2, occurring together, may in general result in more than the sum of the effects of each single cause occurring on its own. These effects may also be interdependent. For example, the extra time-pressure resulting from a change may result in less efficient working, which causes more delay, which adds to the time-pressure.

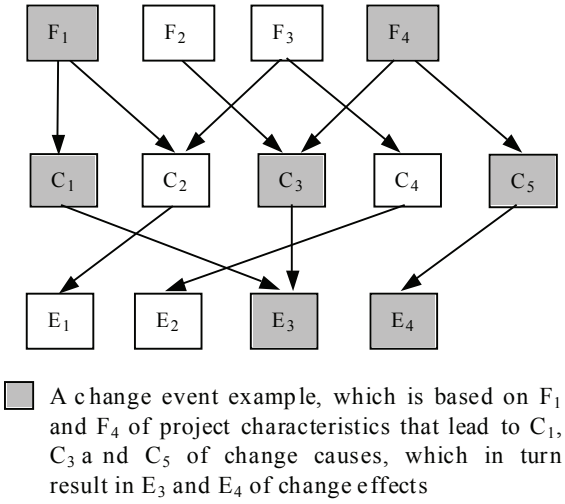

Figure 3: A relationship diagram for a change case

CONCLUSION

This paper has proposed a change process model that is intended to enable project teams to manage change effectively. The approach for developing this process model has considered various factors that affect decisions to change for various construction disciplines. Comprehensive details were given to each stage of the change process model. The main project characteristics that lead to change, the main change causes in construction projects and the main change effects were also identified. The approach has also addressed the cause-and-effect relationships of change.

The generic change process model presented and the proposed cause-and-effect relationship are complementary. The generic model is used to monitor the process of implementing changes. The cause-and-effect relationship model is useful in dealing with proactive changes by addressing the main project characteristics that have an influence on change causes. It can also be used for change diagnosis when they actually occur. There are no predefined relationships between each set of variables with another. Every project has its own case. In each case, the amount of a certain effect is generally due to certain causes of change under specific project characteristics. The proposed approach for tackling a change event gives a clearer view at the early stages of projects, which is useful in alerting the most effective project characteristics that may lead to change in order to take corrective actions and to minimise certain effects of change. Modelling the relationship between change causes and effects shows the need for further research to:

- Determine the likelihood of occurrence of each change cause with respect to each project characteristic.
- Consider multiple causes of change to determine the corresponding impacts on projects.

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Appendix I

1. Pre Change
   - 1.1. Allocate resources for change management function
   - 1.2. Initiate and select change management process for project
   - 1.3. Approaches towards change management
     - 1.3.1. Proactive or reactive change management approaches
     - 1.3.2. Determine acceptance criteria for pre and post design fixity changes
     - 1.3.3. Change implementation style
     - 1.3.4. Determine criteria to indicate voluntary or involuntary imposition of change
     - 1.3.5. Scaleable change management processes
   - 1.4. Align project elements to change management process
   - 1.4.1. Project requirements
     - 1.4.1.1. Time
     - 1.4.1.2. Cost
     - 1.4.1.3. Quality requirements
     - 1.4.1.4. Other stakeholder requirements
   - 1.4.2. Project organisation
     - 1.4.2.1 Group Dynamics
     - 1.4.2.2. Communications structure
     - 1.4.2.3. Co-ordination and leadership
     - 1.4.2.4. The site management
   - 1.4.3. Project execution
     - 1.4.3.1. The complexity of the work
     - 1.4.3.2. Procurement and Supply chain
     - 1.4.3.3. Statutory compliance
     - 1.4.3.4. Type of contract and risk allocation
   - 1.4.4. Select Project Controls
     - 1.4.4.1. Change control mechanisms
     - 1.4.4.2. Human and organisational behaviour management tools
     - 1.4.4.3. Information structure and systems
     - 1.4.4.4. Process and planning tools
       - 1.4.4.4.1. Scenario planning and simulation
       - 1.4.4.4.2. Traditional or sequential planning
     - 1.4.4.5. Tools and techniques that support decision making
       - 1.4.4.5.1. Linear models
       - 1.4.4.5.2. Financial models and parameters to control the operation at any one time
       - 1.4.4.5.3. Multi-attribute utility models that combine qualitative and quantitative decision criteria
       - 1.4.4.5.4. Fuzzy set models
       - 1.4.4.5.5. Artificial Inte lligent systems
       - 1.4.4.5.6. Statistical models to evaluate quantitative criteria
2. Identify and evaluate change
   - 2.1. Monitor deviations from project programme
   - 2.2. Analyse and consider implications of identified deviations
     - 2.2.1. Types of change
       - 2.2.1.1. The Size of the change
       - 2.2.1.2. The timing of the change
         - 2.2.1.2.1. Pre fixity change
         - 2.2.1.2.2. Post fixity change
       - 2.2.1.3. The voluntary or involuntary imposition of change
     - 2.2.2. Consult dependency framework
       - 2.2.2.1. Change Causes
       - 2.2.2.2. Change consequences
     - 2.2.3. Initiator of change
       - 2.2.3.1. Change initiated by the client
       - 2.2.3.2. Change initiated by the Design team
       - 2.2.3.3. Change initiated by the Contractor
       - 2.2.3.4. Change initiated by the supply chain
       - 2.2.3.5. Change initiated by the occupier
   - 2.3. Develop mitigation strategy for change event
     - 2.3.1. Manage and update project controls
       - 2.3.1.1. Introducing acceleration measures to maintain the project programme
       - 2.3.1.2. Maintain information structure and systems
       - 2.3.1.3. Manage change control mechanisms
       - 2.3.1.4. Manage contract and risk allocation
       - 2.3.1.5. Manage process and planning tools
       - 2.3.1.6. Manage human and organisational behaviour management tools
       - 2.3.1.7. Execute selected Decision support tools
     - 2.3.2 Evidence and perform quantitative and qualitative measures
       - 2.3.2.1. Develop measurement metrics
       - 2.3.2.2. Determine source of change
     - 2.3.3. Non determination of change source reiterate process
   - 2.4. Update change management repository
3. Change approval
   - 3.1. Approval process
4. Post change review
   - 4.1. Measure change effectiveness
     - 4.1.1. Modification in physical properties
     - 4.1.2. Changes in control systems
     - 4.1.3. Changes in processes
     - 4.1.4. Project and organisational performance criteria
   - 4.2. Analyse work inactivity and ineffective work

Appendix II

1. Project characteristics
   - 1.1. Economic Issues
   - 1.2. Demographic issues
   - 1.3. Technological Issues
     - 1.3.1. Inappropriate use of technology
     - 1.3.2. Lack of integration
     - 1.3.3. Changes/updates to available technology
     - 1.3.4. The incorporation of new technology
   - 1.4. Customer / stakeholder issues
     - 1.4.1. External pressures bearing on client (re-location, changing needs)
     - 1.4.2. Perform stakeholder impact analysis
     - 1.4.3. Role of client (profile and participation)
   - 1.5. Legislative issues
     - 1.5.1. Building and statutory regulations
     - 1.5.2. National and international governmental policy
   - 1.6. Competitor issues
     - 1.6.1. Monitor competitor's service and cost
     - 1.6.2. Perform market research to ensure (Asset) product viability
   - 1.7. Environmental issues
     - 1.7.1. Environmental lobby Groups
     - 1.7.2. Legislation and statutory regulations pertaining to environmental considerations
     - 1.7.3. Perform environmental impact and risk analysis

2. Organisational/Project change causes
   - 2.1. Process related issues
     - 2.1.1. Organisational Business objectives
     - 2.1.2. Organisational Politics
     - 2.1.3. Quality issues
   - 2.2. People issues
     - 2.2.1. Communication and co-ordination
     - 2.2.2. Misinterpretation of the brief
     - 2.2.3. Project teamwork
     - 2.2.4. Project participant's Skills and knowledge
     - 2.2.5. Uncertainty amongst the team
     - 2.2.6. Team leadership
     - 2.2.7. Human errors
     - 2.2.8. Ambiguity in the roles of the team members
     - 2.2.9. Delays in decision making
     - 2.2.10. Cultural issues
     - 2.2.11. Management structure and system
   - 2.3. Resource related issues
     - 2.3.1. Technical capabilities
     - 2.3.2. Financial aspects
     - 2.3.3. Communications
   - 2.4. Design process change issues
     - 2.4.1. Design errors/ omissions
     - 2.4.2. Concurrency between tasks
     - 2.4.3. Technical aspects of the design
     - 2.4.4. Revised client requirements
     - 2.4.5. Co-ordination of tender documents
     - 2.4.6. Innovations and complexity
     - 2.4.7. Schedule pressure
     - 2.4.8. Design Improvements/modifications
     - 2.4.9. Design Information
     - 2.4.10. Constructability issues
   - 2.5. Construction process change issues
     - 2.5.1. Minor field originated changes
     - 2.5.2. On site management
     - 2.5.3. Damage and accidents
     - 2.5.4. Unforeseen Events and site conditions
     - 2.5.5. Construction technology issues
     - 2.5.6. Workmanship
     - 2.5.7. Work complexity
     - 2.5.8. Difficulties in work execution and control methods

3. Change Effects
   - 3.1. Direct Consequences of change
     - 3.1.1. Cost overrun
       - 3.1.1.1. Planned cost with actual cost
       - 3.1.1.2. Determine and quantify form of penalty or consequence
       - 3.1.1.3. Determine parties affected by the cost overrun
       - 3.1.1.4. Interrupted cash flow
       - 3.1.1.5. Lower profit earnings
     - 3.1.2. Rework
       - 3.1.2.1. Addition of work (additive changes)
       - 3.1.2.2. Deletion of work (deductive changes)
     - 3.1.3. Time overrun
       - 3.1.3.1. Determine whether Duration is according to schedule
       - 3.1.3.2. Determine parties affected by the Time overrun
       - 3.1.3.3. Determine and quantify form of penalty or consequence
       - 3.1.3.4. Re-organise and schedule the work methods, production schedules and deliveries
       - 3.1.3.5. Loss of float
     - 3.1.4. Non conformance to quality standards
   - 3.2. Indirect Consequences of change
     - 3.2.1. Loss of workflow
     - 3.2.2. Uncertainty
     - 3.2.3. Claims and disputes
     - 3.2.4. Loss of learning curve effect
     - 3.2.5. Wastage of resources
     - 3.2.6. Unstable team dynamics
     - 3.2.7. Overtime
     - 3.2.8. Increased co-ordination failures and errors
     - 3.2.9. Low morale
     - 3.2.10. Lower productivity